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DIAGNOSTIC-FEASIBILITY STUDY OF DAWSON LAKE

by
Raman K. Raman and Donald H. Schnepper

Prepared for the
Illinois Department of Conservation

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INTRODUCTION

The Water Quality Section of the Illinois State Water Survey undertook a detailed and systematic diagnostic-feasibility study of Dawson Lake commencing May 1, 1985. The major objectives of the study were to delineate the existing lake conditions, to examine the causes of degradation if any, and to identify and quantify the sources of nutrients and pollutants flowing into the lake. On the basis of the findings of the diagnostic study, the need for watershed and lake management alternatives was examined.

Dawson Lake is located in Moraine View State Park in McLean County. It is a 150-acre lake with a maximum depth of 25.6 feet. The lake was formed in 1963 by the impoundment of North Fork Salt Creek. This publicly owned lake and the surrounding park are managed by the Illinois Department of Conservation for outdoor recreational activities. These include bank fishing, boat fishing, ice fishing in season, boating, canoeing, camping, picnicking, hiking, horseback riding, and winter sports. Bow hunting for deer, and hunting in season for pheasants, doves, woodcocks, rabbits, quails, and squirrels are permitted in the state park. The location map for the lake, indicating state, county, and municipal boundaries, is shown in figure 1. Other relevant general information is included in table 1.

The state park is open year-round from 6:00 a.m. till 10:00 p.m. with easy vehicular access. Access within the park facilities is by foot only when weather conditions necessitate the closing of roads during freezing and thawing periods, usually for a month during very early spring. The park has 138 class B trailer pads, 30 class B equestrian pads, and 60 class D tent pads.

The park formerly offered free interpretive programs through nature walks, tours, campfire events, etc. These are no longer offered because of budget cuts. However, self-guided nature trails, backpack camping, and hiking trails on moderate terrain are available for hikers and primitive campers. Over 10 miles of bridle paths wind through the park.

Two separate one-day annual events are organized by the park personnel. The triathlon event consisting of 1/3 mile of swimming, 4 miles of running, and 12 miles of bicycling, all within the state park, attracts about 130 participants and 300 spectators. The Moraine View Cross-Country Ski Classic generally draws about 150 participants and 200 spectators.

During the 1986 season, 5176 pheasants were released under the put-and-take program, and 2029 hunters participated in the pheasant hunting. The hunters bagged a total of 2798 pheasants.

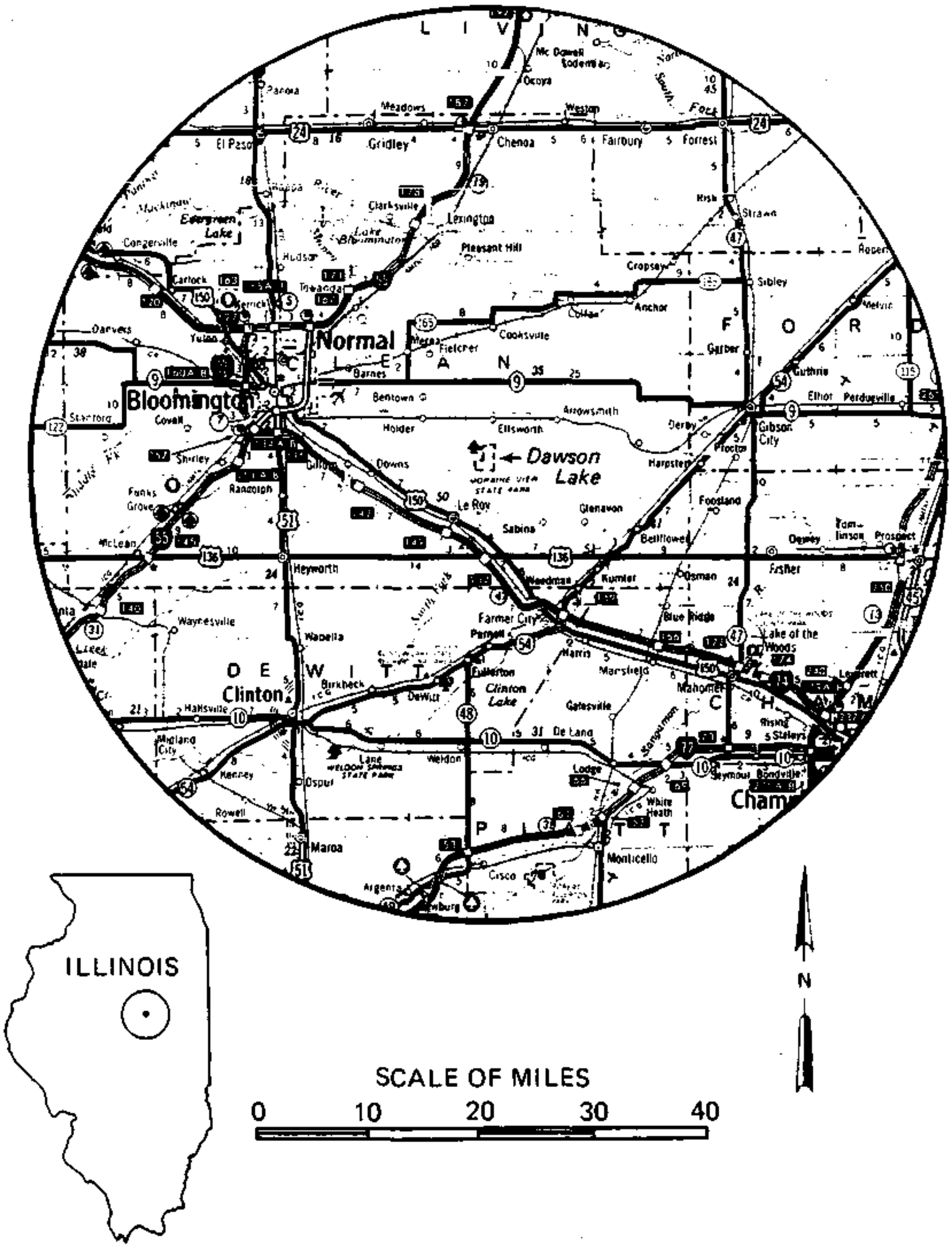

Figure 1. Location map, Dawson Lake

Table 1. General Information Pertaining to Dawson Lake

Lake name	Dawson Lake
County	McLean; Section 35, T23N, R4E
Nearest municipality	LeRoy, Illinois
Latitude	40°-24'-12" N
Longitude	88°-43'-24" W
IEPA major basin name and code	Upper Mississippi River, 07
IEPA minor basin name and code	Illinois River, 17
Major tributary	North Fork Salt Creek
Receiving water body	Sangamon River via Salt Creek
Water quality standards	General standards promulgated by the Illinois Pollution Control Board and applicable to waters designated for aquatic life

A concession stand near the lake is open every day throughout the summer. In addition to the normal amenities provided by concession stands, it has facilities for rental of boat slips, rowboats, pontoon boats,' canoes, and paddle boats.

Acknowledgments

This investigation, funded by the Illinois Department of Conservation, was conducted under the general supervision and guidance of the Chief of the Illinois State Water Survey Division, Department of Energy and Natural Resources.

Several Water Survey staff members contributed to this investigation. David Hullinger and Dana Shackleford performed chemical analyses; Thomas Hill and Davis Beuscher identified benthic organisms; Davis Beuscher performed bacterial analyses and algal identification and enumeration; Tom Butts, Doug Excell, and Harvey Adkins carried out the in-situ determinations of sediment oxygen demand rates; Robert Sinclair, David Soong, and Paul Makowski provided valuable guidance in computer data management; and William Fitzpatrick and David Green carried out the lake sediment and bathymetric surveys.

Linda Johnson typed the manuscript and prepared the camera ready copy; Gail Taylor edited the manuscript; and John W. Brother, Jr., and Lynn Weiss prepared the illustrations.

The cooperation, assistance, and courtesy extended by Lynn Norman and his staff of Moraine View State Park, Illinois Department of Conservation, are appreciated very much. Kim Scace, special programs engineer, was the project manager and her assistance in the administration of the project was very valuable. Gary Lutterbie, fishery biologist, provided historical water quality data and information pertaining to the chemical control of lake vegetation.

Gary Fak of the Soil Conservation Service provided data on land use, soil types, and soil conservation practices adopted within the lake watershed.

STUDY AREA

Dawson Lake

Dawson Lake is located in Moraine View State Park in McLean County. It is situated about 14 miles southeast of Bloomington-Normal and about 6 miles north of LeRoy, both on Interstate Highway 74. The park is easily accessible from I-74 and Highways 9 and 150. The lake was formed in 1963 by the impoundment of North Fork Salt Creek. The lake currently has a water surface area of 150 acres with a maximum water depth of 25.6 feet. Other pertinent morphometric details regarding the lake are included in table 2.

The impoundment was created only for recreational purposes, with no other designated uses. It is stocked and managed by the Department of Conservation for warm-water fish such as largemouth bass, bluegill, redear sunfish, bullhead, crappie, northern pike, and catfish. Public access to the lake exists as indicated in figure 1. A ramp and docks for private and rental boats are provided on the west shore near the concession stand, and there is a boat ramp on the east shore near the camping area. Fishing access and piers for handicapped persons are provided in strategic locations along the western shore of the lake. Boats other than those that are manually propelled are limited to 10-horsepower outboard motors. A bathymetric map of the lake is shown in figure 2.

Geological and Soil Characteristics of the Drainage Basin

Dawson Lake, the dam, and the state park are located in the Lowlands Province, Bloomington Ridged Plain of the Till Plain Section. This area is characterized by a concentric system of morainal ridges alternating with till plains. Low, broad morainic ridges alternating with intervening wide stretches of relatively flat or gently undulating till plains are found

Table 2. Morphometric Details regarding Dawson Lake

Surface area, acres	150.0
Volume, acre-feet	1475.0
Mean depth, feet	9.3
Maximum depth, feet	25.6
Length of shoreline, miles	5.4
Average retention time, years	1.98
Total original capacity loss, percent	8.8
Annual capacity loss, percent	0.4
Watershed area, acres	2828.0

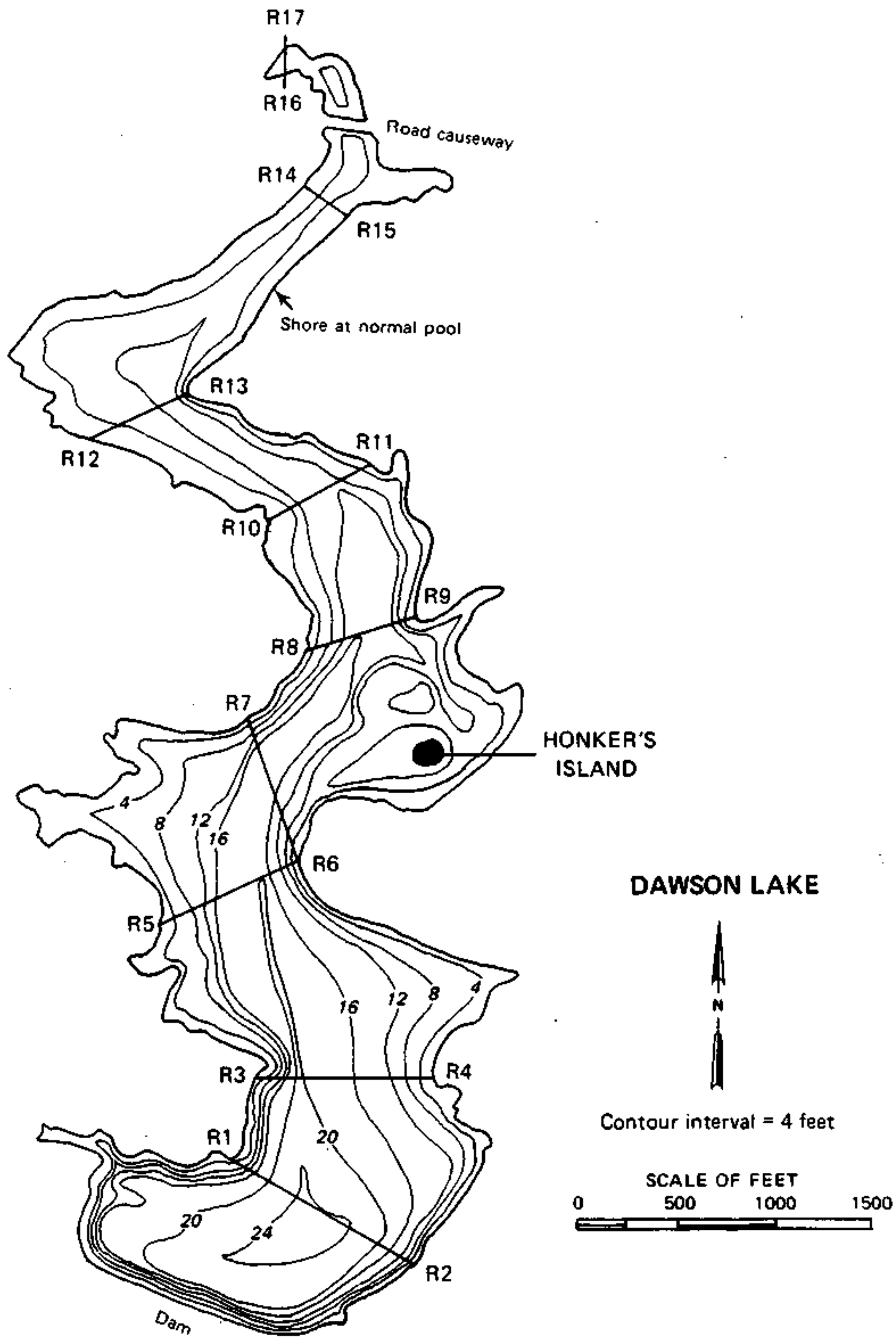

Figure 2. Bathymetric map of Dawson Lake

throughout this section. Glacial deposits of Wisconsinan age are relatively thick, and exposures of bedrock are seldom encountered.

Bedrock in the area consists of the Bond and Mattoon Formations of the Pennsylvanian System. Rock types would be expected to consist of interbedded layers of limestone, sandstone, shale, and coal. According to coal maps, no undermining of coal has occurred in the Dawson Lake area. Because of its great depths, bedrock is not a factor at this site.

The state park is located on the LeRoy Moraine. The soils in upland areas would be expected to consist of 4 to 6 feet of loess underlain by glacial till. The till in this area is the Batestown Till member of the Wedron Formation. The Batestown is a gray silty till that oxidizes to olive brown. The overburden in this area is 200 to 300 feet thick.

The major soils in the watershed are Catlin, Saybrook silt loam, and Muscatine along with Sable, Strawn, and Birkbeck. Catlin is generally very dark gray to very dark grayish brown friable silt loam with a pH of 5.6 to 7.3 and a moderate organic content of 3.5 percent. Its natural drainage capability ranges from moderately well drained to well drained. Surface features of this soil make it very susceptible to erosion.

Saybrook silt loam is a naturally well drained dark-colored upland prairie soil usually occurring on slopes of from 1 to 7 percent. Air and water move freely in this soil, and there are no obstructions to deep root growth. This soil has a high water-supplying capacity and is highly productive when properly managed. It has developed from 12 to 30 inches of loess over calcareous loam textured glacial till. This soil is generally suited for cropland, permanent pasture, and woodland.

Muscatine is very dark brown to black friable silty clay loam. Organic content in the soil is high: about 4.5 percent. It is somewhat poorly drained. The seasonal high water table is generally within 2 to 5 feet of the surface. The soil is susceptible to erosion.

Table 3 shows the soil types encountered in the Dawson Lake watershed, including the slope categories, acreages, and agricultural suitability classifications. This information pertains to the watershed area outside the state park owned by the Illinois Department of Conservation. Similar information is not currently available for the state park land areas.

Public Access to the Lake Area

There is no public transportation available for use to and from the lake and the state park. However, Highways 9 and 150 and Interstate Highway 74 provide easy access to the park area from Bloomington-Normal and LeRoy, IL.

A public road circles the lake, providing easy access to such activities as bank fishing, hiking, picnicking, boat launching, and horseback riding. Strategic lookout points with adequate parking facilities also exist around the lake. A map of the lake, identifying public access

Table 3. Soil Types in Dawson Lake Watershed

Soil type	Slope range (percent)	Area (acres')	Capability class*
Dodge	2-5	12	2
Muscatine	0-2	165	1
Lisbon	0-2	63	1
LaRose	5-10	12	2
Sable	0-2	441	2
Saybrook silt loam	2-5	224	2
Saybrook silt loam	2-5	67	2
Saybrook silt loam	5-10	141	3
Flanagan	0-2	61	1
Catlin	2-5	370	2
Catlin	2-5	272	2
Strawn	5-10	75	3
Birkbeck	2-5	91	2
Birkbeck	5-10	6	2

*1 - may be safely used for cultivated crops, 2 - simple conservation practices are needed when cultivated, 3 - requires more difficult or complex conservation practices when cultivated

points and facilities, is given in figure 3. Pertinent information on access points is tabulated in table 4.

Potential User Population

The park resident population consists of the site superintendent and conservation police officer and their families. LeRoy and Bloomington-Normal, which are located within 14 miles of the state park, have populations of about 2900 and 90,000 respectively. The state park draws daily and weekend visitors from these two population centers. Other Illinois population centers reasonably close to the lake area are Lincoln, Decatur, Champaign-Urbana, Rantoul, and Pontiac. All of these are within a 40-mile radius of the park. The combined population of these cities is in excess of 225,000. The proximity of Interstate Highway 74 (figure 1) facilitates visits by interstate travelers.

The economic base of Bloomington-Normal, IL, is a diversified mixture of commerce, agribusiness, light industries, higher education, and services related to auto, life, and real estate insurance. Location of the Chrysler-Mitsubishi automotive assembly plant in the Bloomington-Normal area has provided a tremendous economic boost to the area, attracting several other supporting light manufacturing, service, and commercial enterprises. Commercial and residential construction activities have begun to increase in pace since the announcement of the selection of the area for the automobile plant. There are no housing shortages and no urban blight in the twin-cities area.

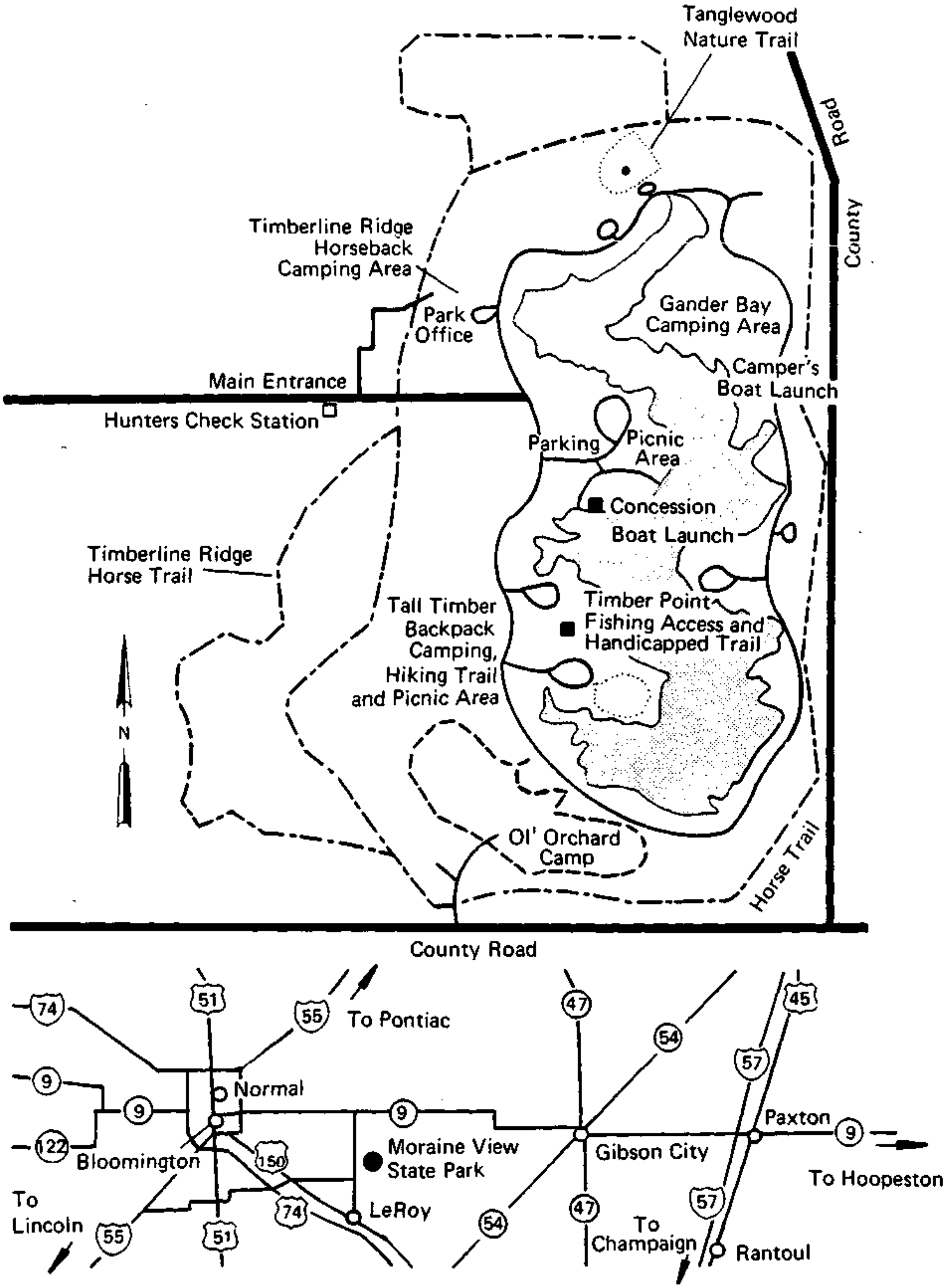

Figure 3. Public access points and facilities in Dawson Lake

Table 4. Public Access Points in Dawson Lake

Location	Type	Land area (acres)	Lake frontage (feet)	Facilities
Concession stand landing	Two-lane boat launch	1.5	1200	Parking for 75 vehicles and trailers, two picnic areas, and playground equipment
Wild Sumac picnic area	Handicapped fishing dock	0.75	250	Parking for 15 vehicles, picnic area, playground equipment
Willow Marsh	Fishing access	0.50	150	Ten parking spaces, walking trail
Gander Bay camping area	Boat launch and dock	12.0	1000	Camping facilities for trailers and recreational vehicles, space for 150 vehicles
Honker's Island	Picnic area	1.0	300	Parking for 15 vehicles
Black Locust	Picnic area	4.0	400	Parking for 100 vehicles, sandy swimming beach
Basin View	Fishing	2.0	150	Parking for 15 vehicles
Lonesome Hawthorne	Fishing and picnicking	1.0	400	Parking for 25 vehicles
Tall Timber	Camping, hiking, and picnicking	3.0	600	Parking for 25 vehicles
Catfish Bay	Camping, fishing, and picnicking	5.0	600	Parking for 20 vehicles

Detailed information related to the potential user population, including the major nearby population centers and pertinent economic characteristics, is given in table 5. It is known that the park facilities attract visitors from a wide area, with past attendance topping 578,680 in one year.

Historical Lake Uses and Conditions at Dawson Lake

The impoundment was created for recreational purposes only, with fishing as the primary recreational use. The lake is used for ice fishing during winter months. Power boats with a 10-horsepower limit are allowed in addition to rowboats and paddle boats. Swimming is permitted at the designated area. Rental paddle boats and canoes are available for public use at the lake site.

Moraine View State Park is a popular recreational facility in the region and draws hundreds of thousands of visitors each year. The historical data on park attendance are shown in table 6. The data shown in the table are for total park usage. Information on the number of users for different recreational categories is not available.

The data in table 6 indicate that there has been a trend of increasing park attendance from year to year. Fishing and various hunting activities contribute to the immense popularity of the lake and the park area.

The lake was treated chemically to control aquatic vegetation as early as 1965, within three years of its formation. It has routinely been subjected to applications of herbicides for controlling submerged macrophytes every year since then with the exception of 1972, 1974, 1975, 1979, 1981, and 1983. The lake was treated with copper sulfate during 1967, 1971, 1973, 1977, 1980, and 1982 to control algae. The copper sulfate dosage used each year was 300 pounds or less. This is much less than the dosage of 810 pounds (at the rate of 5.4 pounds per acre for 150 acres) for each application indicated in the literature. It is presumed that copper sulfate was used to treat selected shoreline areas instead of the whole lake. Unlike in other IDOC lakes (Kothandaraman and Evans, 1983a, 1983b), algal blooms and dense attached filamentous algal growths have not been observed in Dawson Lake.

Uncontrolled sediment transport from the agricultural land parcels within the watershed generally resulted in the sedimentation of the upper end of the lake in the past. Another inherent problem for man-made lakes in central and northern Illinois is the total depletion of oxygen in the hypolimnetic zone during summer months. Such conditions severely restrict fish habitats and alter the character and species makeup of the benthic macroinvertebrates in the profundal region of the lake.

Point Source Waste Discharge

Backwash water from the Moraine View State Park water treatment plant is the only point source waste discharged in the watershed of the lake. The

Table 5. Population and Economic Data for Areas near Dawson Lake
(Population and dollar figures are in thousands)

County and population	Major city within the county and its population	Employment sources and numbers of people employed*	Retail sales (thousands of dollars)
Champaign, 168.4	Champaign-Urbana, 93.7	B,C,G,H,K, 78.5	997,214
Christian, 36.6	Taylorville, 11.2	A,B,C,G,H,K,L, 14.4	164,762
DeWitt, 18.8	Clinton, 7.8	A,B,C,D,E,G,H,K, 7.7	71,678
Ford, 14.7	Paxton, 4.3	A,B,C,F,G,H,K,L, 6.6	55,030
Iroquois, 32.8	Watseka, 1.6	A,B,C,F,G,K, 14.0	118,684
Kankakee, 104.1	Kankakee, 26.4	B,C,G,K, 42.5	478,850
LaSalle, 111.2	Ottawa, 10.3	A,B,C,G,K, 47.4	613,618
Livingston, 42.4	Pontiac, 11.2	A,B,C,G,K,L, 17.5	170,743
Logan, 31.5	Lincoln, 8.5	A,C,G,K,L, 13.9	136,837
Macon, 131.7	Decatur, 94.0	B,C,D,G,H,K, 56.5	763,499
Marshall, 14.4	Lacon, 2.1	A,C,G,K, 5.9	30,775
Mason, 19.7	Havana, 2.7	A,B,C,G,K, 7.2	67,355
McLean, 125.1	Bloomington-Normal, 90	A,B,C,G,K, 57.2	772,241
Moultrie, 15.0	Sullivan, 4.5	A,B,C,G,K, 6.0	49,226
Piatt, 17.1	Monticello, 4.8	A,B,C,G,K, 7.4	49,702
Sangamon, 182.9	Springfield, 99.6	B,C,G,H,K,L, 85.5	1,122,987
Tazewell, 134.7	Pekin, 29.9	B,C,G,H,K, 57.9	646,697
Vermilion, 94.1	Danville, 27.2	C,G,K, 38.7	540,160
Woodford, 35.2	Eureka, 3.8	A,B,C,F,G,H,K, 14.4	108,472

* A - agriculture, forestry, fisheries, and mining; B - construction; C - manufacturing; D - transportation; E - communication and other public utilities; F - wholesale trade; G - retail trade; H - finance, insurance, and real estate; I - business and repair services; J - personal, entertainment, and recreational services; K - professional and related services; and L - public administration.

Sources: Supplementary Report, Advance Estimates of Social, Economic, and Housing Characteristics - Illinois - U.S. Department of Commerce, Bureau of the Census, PH080-S2-15. Advance Reports, 1980 Census of Population and Housing, U.S. Department of Commerce, Bureau of the Census, PH080-V-15. Sales and Marketing Management, July 28, 1986, 1986 Survey of Buying Power, Part I.

backwash water is passed through a sand bed filter to capture the suspended sediments prior to discharge to the lake.

The water treatment plant has a rated capacity of 100 gpm with a filter area of 38.2 square feet at a filtration rate of 2.62 gpm/sq ft. The filtering media consist of 24 inches of #1 anthracite over 16 inches of graded gravel. The aeration blower has a rated capacity of 470 cfm at 3/8" SP driven by a 1/6-HP motor.

Table 6. Historical Data on Park Attendance

Year	No. of visitors
1975	255,655
1976	335,292
1977	578,681
1978	373,528
1979	374,374
1980	391,986
1981	415,491
1982	432,683
1983	449,381
1984	487,711
1985	508,436
1986	553,371

The recommended backwash rate is 10.4 gpm/sq ft for 10 minutes. The total volume of wastewater generated for each backwash is 4000 gallons. The backwash cycle is initiated on a varied frequency ranging from once in 10 to 14 days during the period May 1 to September 30 to once every 7 days during October 1 to April 30.

Lakes within a 50-mile Radius of Dawson Lake

There is no other publicly owned lake within a 25-mile radius of Dawson Lake. The lake and the state park are unique resources providing recreational activities such as fishing, boating, camping, picnicking, horseback riding, and hunting.

There are seven lakes with public access and with surface areas of more than 10 acres within a 50-mile radius of Dawson Lake. Information on their areas and maximum depths, as well as on the presence of launching ramps and the recreational facilities available at these sites, is given in table 7.

Land Uses

The watershed for the lake is approximately 2828 acres, of which about 800 acres (28.3 percent) is now in state ownership. Information on the land uses in the watershed is given in table 8. The land use information was obtained from the McLean County Soil Conservation Service office.

There are 21 farmland parcels within the lake watershed. The McLean County Soil and Water Conservation District in cooperation with the Soil Conservation Service has instituted several soil conservation practices in the watershed. The District reports that as of 1986, about 878 acres of farmland have been adequately protected, with another 637 acres in conservation tillage. There are about 9600 feet of terracing in the watershed. The District Conservationist estimates that the soil loss from the farmland has been reduced from 6554 tons/year to 2622 tons/year with all

Table 7. Public Access Lakes within Fifty Miles of Dawson Lake

Name of lake	Area (acres)	Maximum depth (feet)	Launching ramp	Recreational facilities*
Champaign County				
Homer Lake	80.8	24.0	Yes	4,6,7,9,10
Lake of the Woods	22.5	28.0	Yes	4-10,13
DeWitt County				
Weldon Springs Lake	29.4	28.0	Yes	1-14
Macon County				
Lake Decatur	3093.0	28.0	Yes	1,2-7,9,10,16
Sangamon County				
Lake Springfield	42340.0.	30.0	Yes	1,2,4-7,9,10
Tazewell County				
Brock Lake	10.3	17.0	Yes	1,4-7,9,10
Spring Lake	1285.0	11.0	Yes	1,3,4,6,7,9-14,17

* 1 - camping; 2 - electricity; 3 - sanitary dump; 4 - picnicking; 5 - refreshments; 6 - drinking water; 7 - toilets; 8 - museum; 9 - fishing; 10 - boating; 11 - boat rentals, 12 - motorboats; 13 - hiking; 14 - horse trails; 15 - horse campground; 16 - hunting; 17 - ski rentals

Table 8. Dawson Lake Watershed Land Uses

Type of land use	Area (acres)	Percent of total
Cropland and farmsteads	1851	65.5
Pasture	100	3.5
Woodland	49	1.7
Recreational development		
State park	650	23.0
Lake	150	5.3
Other water bodies	28	1.0
Total	2828	100.0

the conservation practices in place. The soil loss is thus estimated to be at or below tolerable limits. The District Conservationist is of the opinion that every practice that could be economically implemented to control soil erosion in the watershed has been adopted and is being utilized.

In addition to the conservation practices applicable to specific agricultural tracts, the District has taken additional measures to minimize soil erosion in the watershed. These include the use of 40-foot-wide grass waterways to separate farmed areas from adjacent streams, and use of a 4-year crop rotation consisting of wheat with alfalfa and brome mix in the first year, alfalfa and brome with no harvest in the second year, corn in the third year, and beans in the fourth year. After the bean harvest, the field is chiseled and sown to winter wheat with alfalfa and brome mix. No fall plowing is used except after the fourth year of crop rotation.

LIMNOLOGICAL ASSESSMENT OF THE LAKE

Materials and Methods

To assess the current conditions of the lake, certain physical, chemical, and biological characteristics of the lake were monitored at two lake stations (one deep and one shallow) from May 1985 to May 1986. The lake was monitored on a biweekly schedule from May through September 1985 and on a monthly schedule thereafter. Ice conditions in the lake (ice too thin to walk on and too thick to use a boat) prevented lake monitoring during December 1985 and January and February 1986. Biweekly monitoring was resumed on March 18, 1986 and was terminated on May 27, 1986. During the entire period, a total of 19 lake monitoring visits were made. During these visits water samples also were collected from the main tributary upstream and downstream of the lake for chemical and biological characterization. The locations of the lake and tributary monitoring stations are shown in figure 4.

In-situ observations for temperature, dissolved oxygen, and secchi disc readings were made at the deep and shallow stations in the lake. An oxygen meter, Yellow Spring Instrument Company Model 54, with a 50-foot probe was standardized in lake surface water in which dissolved oxygen content was determined by the modified Winkler method as outlined by the American Public Health Association et al. (1985). Temperature and dissolved oxygen measurements were obtained in the water column at 2-foot intervals at the deep station and at 1-foot intervals at the shallow station, commencing from the surface of the lake.

For measuring secchi disc transparencies, an 8-inch-diameter secchi disc with black and white quadrant markings attached to a calibrated line was used. The disc was lowered until it disappeared from view, and the depth of immersion of the disc was noted. The disc was lowered farther and then raised slowly until it reappeared. Again the depth of immersion was noted. The average of these two observations was recorded as the secchi disc reading.

Water samples for chemical analyses were obtained from the lake with a Kemmerer sampler at points 1 foot below the surface, mid-depth, and 1 foot from the bottom. Integrated water samples within a depth twice the secchi disc readings were obtained for phytoplankton identification and enumeration, and for chlorophyll-a determination. A Juday sampler was used for obtaining integrated samples. Samples for coliform determination were obtained at 1 foot below the surface in pre-sterilized glass bottles. All the samples were stored on ice during transportation and kept in a refrigerator until processed, with the exception of the algae and chlorophyll-a samples. Chlorophyll-a samples were kept frozen.

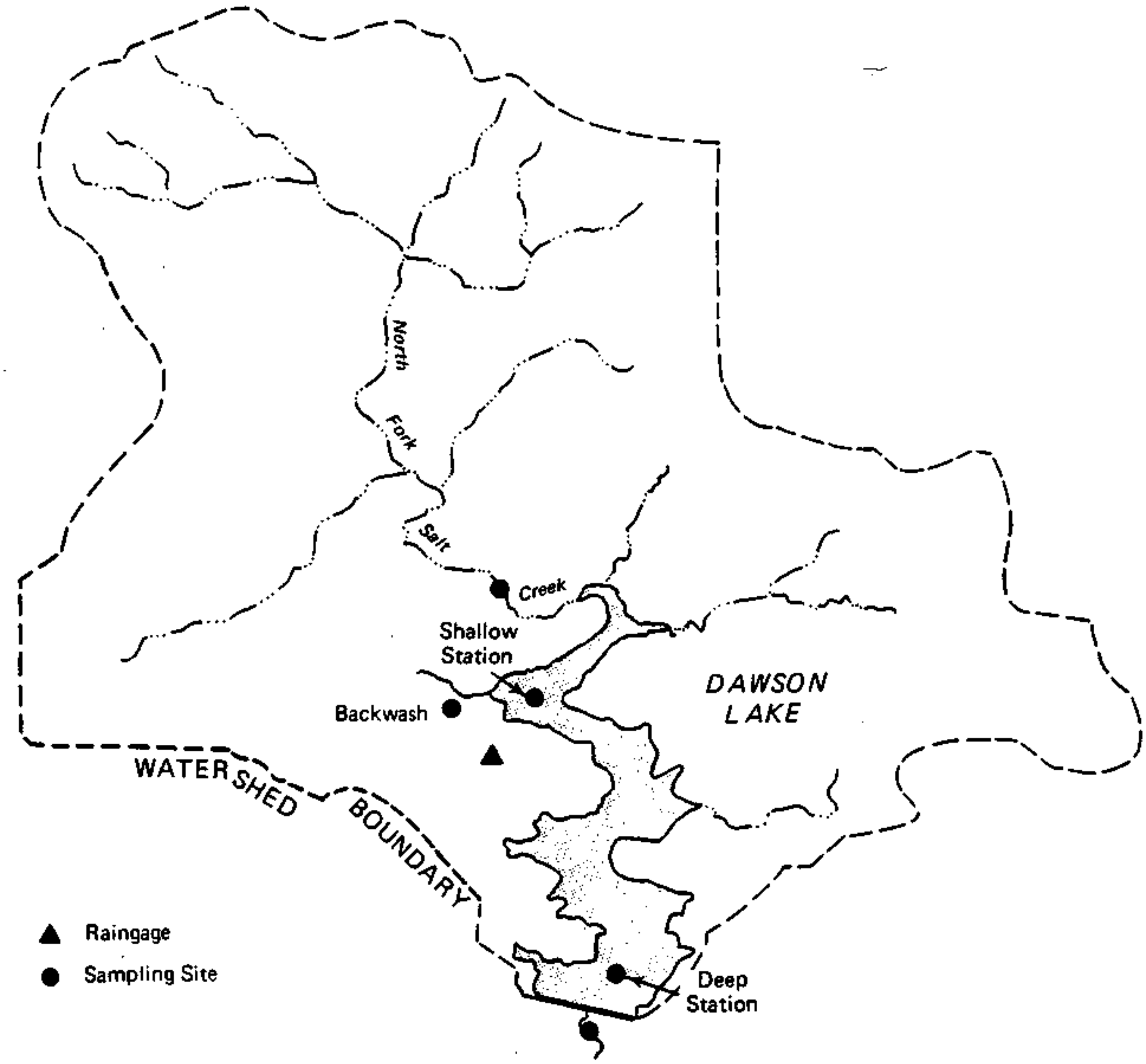

Figure 4. Locations of lake and tributary monitoring stations

Water subsamples in a volume of 380 ml were collected for algal identification and enumeration, preserved with 20 ml of formalin at the time of collection, and stored at room temperature until examined.

Determinations for pH, alkalinity, and conductivity were made at the lake site soon after sample collections. Laboratory analyses were performed to determine total suspended and dissolved solids, volatile suspended solids, turbidity, total and dissolved phosphorus, nitrate-nitrogen, total Kjeldahl-nitrogen, and chlorophyll-a. Streamwater samples were not examined for chlorophyll-a content. The methods and procedures involved in these determinations are given in table 9.

For algal identification and enumeration, the sample was thoroughly mixed and a 1-ml aliquot was pipetted into a Sedgewick Rafter Cell. A

Table 9. Analytical Procedures

Turbidity	Nephelometric method, using Turner Fluorometer, model 110; Formazin used as a standard
pH	Glass electrode method with portable Metrohm-Herisau meter (Model E588)
Total solids	Residue on evaporation overnight on a steam bath at 103-105°C
Suspended solids	Dry weight of solids retained on gooch crucible with fiberglass filter
Suspended volatile solids	Loss on ignition of suspended solids at 550°C in a muffle furnace for 1 hour
Alkalinity	Potentiometric method; titration with a standard sulfuric acid solution to an end point pH of 4.5
Conductivity	Metrohm Herisau Conductometer 5587 corrected for 25°C
Total phosphorus	Sample was digested with sulfuric-nitric acid mixture and determined by ascorbic acid method
Ammonia-N	Endophenol-hypochlorite colorimetrie determination
Nitrate-N	Chromotrophic method
Kjeldahl-N	Digestion and distillation followed by endophenol-hypochlorite colorimetric determination
Chlorophyll-a	Sample was filtered through 0.45um membrane filter, the pigment extracted with 90% acetone (V/V), and concentration determined spectrophotometrically at 665 nm, correcting for absorbence at 750, 645, and 630 nm (Jones and Lee, JAWWA, Vol. 74, No. 9, pp. 490-494).

differential interference contrast microscope equipped with a 10X or 20X eyepiece, 20X or 100X objective, and a Whipple disc was used for identification and counting purposes. Five short strips were counted. The algae were identified as to species and were classified into five main groups: blue-greens, greens, diatoms, flagellates, and others. For enumeration, blue-green algae were counted by trichomes. Green algae were counted by individual cells except for Actinastrum. Coelastrum. and Pediastrum. which were recorded by each colony observed. Scenedesmus was counted by each cell packet. Diatoms were counted as one organism regardless of their grouping connections. For flagellates, a colony of Dinobrvon or a single cell of Ceratium was recorded as a unit.

Lake and stream bacterial samples were examined for total coliform, fecal coliform, and fecal streptococci. Standard Methods procedures (American Public Health Association et al., 1985) using 0.45 um filters were used in the bacterial determinations.

A macrophyte survey of the lake was made on July 29, 1985. Samples of submerged vegetation were obtained with roots intact. The macrophyte beds were probed thoroughly, and representative samples of the various types of vegetation found in the lake were obtained and placed in plastic bags with lake water, which were then sealed. These samples were then examined with a stereo microscope and identified. The areal extent of the submerged vegetation was noted on the lake map.

Benthic samples for macroinvertebrate examination were obtained at monthly intervals during June through September. The bottom muds were also examined for percent moisture and volatile fraction. Benthic samples were obtained at both the deep and shallow stations in the lake.

Three grabs with an Ekman dredge (6 x 6 inches) were taken at each station for macroinvertebrate analyses. The samples were washed in a 30-mesh screen bucket and the residue was placed in quart jars and preserved in 95 percent ethyl alcohol. In the laboratory, the samples were washed again and the organisms were picked from the bottom detritus. They were identified, counted, and preserved in 70 percent ethyl alcohol.

Water consistency (percent water) of the sediment samples was determined by first decanting the supernate from the stored sample and thoroughly mixing it. Loss of weight from the wet samples at 103°C overnight on a steam bath, expressed as percent of original weight, was taken as a measure of the consistency of the sediment sample. The fixed and volatile fractions were determined according to Standard Methods (APHA et al., 1985).

In-situ sediment oxygen demand (SOD) rate determinations were made at the deep and shallow stations of the lake on July 15, 1985. At this time anoxic conditions existed at the deep station.

In-situ measurement of sediment oxygen demand rates consists essentially of confining a known volume of water over a given bottom area. For this investigation, a small box-type sampler 12 x 7 x 6 inches in size, made of 3/16-inch welded steel plate, was used. The dissolved oxygen (DO) drop within the confined waters was monitored with a galvanic cell oxygen probe equipped with a stirrer. The stirrer-probe combination was implanted internally in the sampler. The details regarding the sampler, . field procedures, and SOD rate evaluation techniques have been given by Butts and Evans (1979).

Stage gages were installed for measuring the depth of flows in the stream upstream and downstream of the lake. Daily stage readings were recorded with the help of state park officials. Actual streamflow measurements were made with a current meter to establish stage-discharge relationships for different discharge levels. Rating curves were developed for each location of the stage gages. From the daily stage readings and the rating curves, daily flow volumes were estimated for use in developing hydraulic and nutrient budgets.

An automatic recording raingage was installed in the watershed and was in operation from May 1, 1985 to May 31, 1986. Rainwater samples collected in the raingage were examined periodically for nitrogen and phosphorus content.

On a few occasions, following heavy precipitation in the watershed, water samples were collected from the tributary with the help of park officials. These samples were analyzed for suspended sediments and various forms of nitrogen and phosphorus.

Water Quality Characteristics

Physical Characteristics

Temperature and Dissolved Oxygen. Lakes in the temperate zone generally undergo seasonal variations in temperature through the water column. These variations, with their accompanying phenomena, are perhaps the most influential controlling factors within the lakes.

The temperature of a deep lake in the temperate zone is about 4°C during early spring. As the air temperatures rise, the upper layers of water warm up and mix with the lower layers by wind action. By late spring, the differences in thermal resistance cause the mixing to cease, and the lake approaches the thermal stratification of the summer season. Closely following the temperature variation in water is the physical phenomenon of increasing density with decreasing temperature up to a certain point. These two interrelated forces are capable of creating strata of water of vastly differing characteristics within the lake.

During thermal stratification the upper layer (the epilimnion) is isolated from the lower layer of water (the hypolimnion) by a temperature gradient (the thermocline). Temperatures in the epilimnion and hypolimnion are essentially uniform. The thermocline will typically have a sharp temperature drop per unit depth from the upper to the lower margin. When the thermal stratification is established, the lake enters the summer stagnation period, so named because the hypolimnion becomes stagnated.

With cooler air temperatures during the fall season, the temperature of the epilimnion decreases. This decrease in temperature continues until the epilimnion is the same temperature as the upper margin of the thermocline. Successive cooling through the thermocline to the hypolimnion results in a uniform temperature through the water column. The lake then enters the fall circulation period (fall turnover) and is again subjected to a complete mixing by the wind.

Declining air temperatures and the formation of an ice cover during the winter produce a slight inverse thermal stratification. The water column is essentially uniform in temperature at about 3 to 4°C, but slightly colder temperatures of 0 to 2°C prevail just below the ice. With the advent of spring and gradually rising air temperatures, the ice begins to disappear, and the temperature of the surface water rises. The lake again becomes uniform in temperature, and the spring circulation occurs.

The most important phase of the thermal regime from the standpoint of eutrophication is the summer stagnation period. The hypolimnion, by virtue of its stagnation, traps sediment materials such as decaying plant and animal matter, thus decreasing the availability of nutrients during the critical growing season. In a eutrophic lake, the hypolimnion becomes anaerobic or devoid of oxygen because of the increased content of highly oxidizable material and because of its isolation from the atmosphere. In the absence of oxygen, the conditions for chemical reduction become favorable and more nutrients are released from the bottom sediments to the overlying waters.

However, during the fall circulation period, the lake water becomes mixed, and the nutrient-rich hypolimnetic waters are redistributed. The nutrients which remained trapped during the stagnation period become available during the following growing season. Therefore, a continual supply of plant nutrients from the drainage basin is not mandatory for sustained plant production. Fruh (1967) and Fillos and Swanson (1975) state that after an initial stimulus, the recycling of nutrients within a lake might be sufficient to sustain highly productive conditions for several years.

Isothermal plots for the deep station in Dawson Lake are shown in figure 5. The vertical temperature profiles for the deep station on selected dates are shown in figure 6. From figure 5 it is seen that the summer stratification begins to set in during the latter half of May and intensifies progressively during the summer months. The maximum water temperature of 29.0°C was observed on July 29, 1985. The lake experienced the maximum temperature differential of 7.0°C between the surface and bottom waters on an earlier date: July 15, 1985. Therafter, the intensity of stratification began to decrease except for a brief spell around September 9, 1985. The lake was found to be uniform in temperature after the fall turnover on October 7, 1985.

The intensity of thermal stratification in Dawson Lake is much less than in Johnson Sauk Trail Lake, a 57.4-acre lake in Henry County, Illinois, with maximum and mean depths of 23.0 and 8.2 feet, respectively. The summer stratification in that lake appeared to begin and end at about the same time

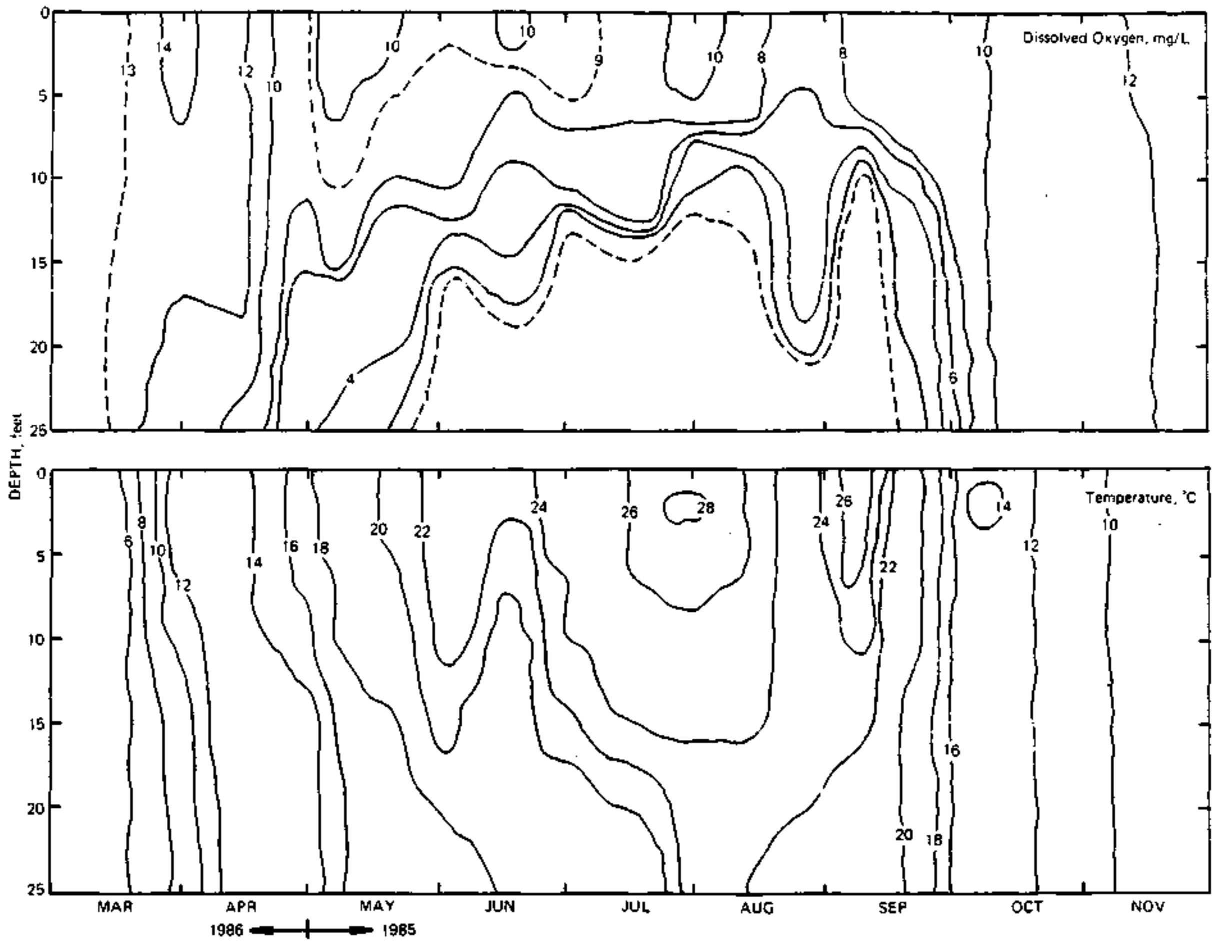

Figure 5. Isothermal and iso-dissolved oxygen plots for the deep station

periods as in Dawson Lake, but the maximum temperature differential between the surface and deep waters was reported to be 12.0°C (Kothandaraman and Evans, 1983a) as opposed to 7.0°C in Dawson Lake. It should be pointed out that the maximum and mean depths of these two lakes are comparable. The differences in the intensities of stratification are attributable to the morphology and topography of their watersheds. Johnson Sauk Trail Lake is situated in a deep ravine surrounded by shoreland with steep slopes and bordered by thick stands of pine, oak, hickory, walnut and other trees. The lake is somewhat protected from wind forces. Dawson Lake, on the. other hand, is located in a relatively flat land area. Also the surface fetch of the lake at the deep sampling station is much longer in Dawson Lake, which is more conducive for wind mixing, thus reducing the intensity of thermal stratification.

Lake stability has long been used by limnologists as an arbitrary measurement of the intensity of stratification in any body of water (Symons, 1969). Stability is calculated in work or energy units. It is defined as the work that must be done to lift the entire weight of a body of water the vertical distance between two centers of gravity: the center of gravity

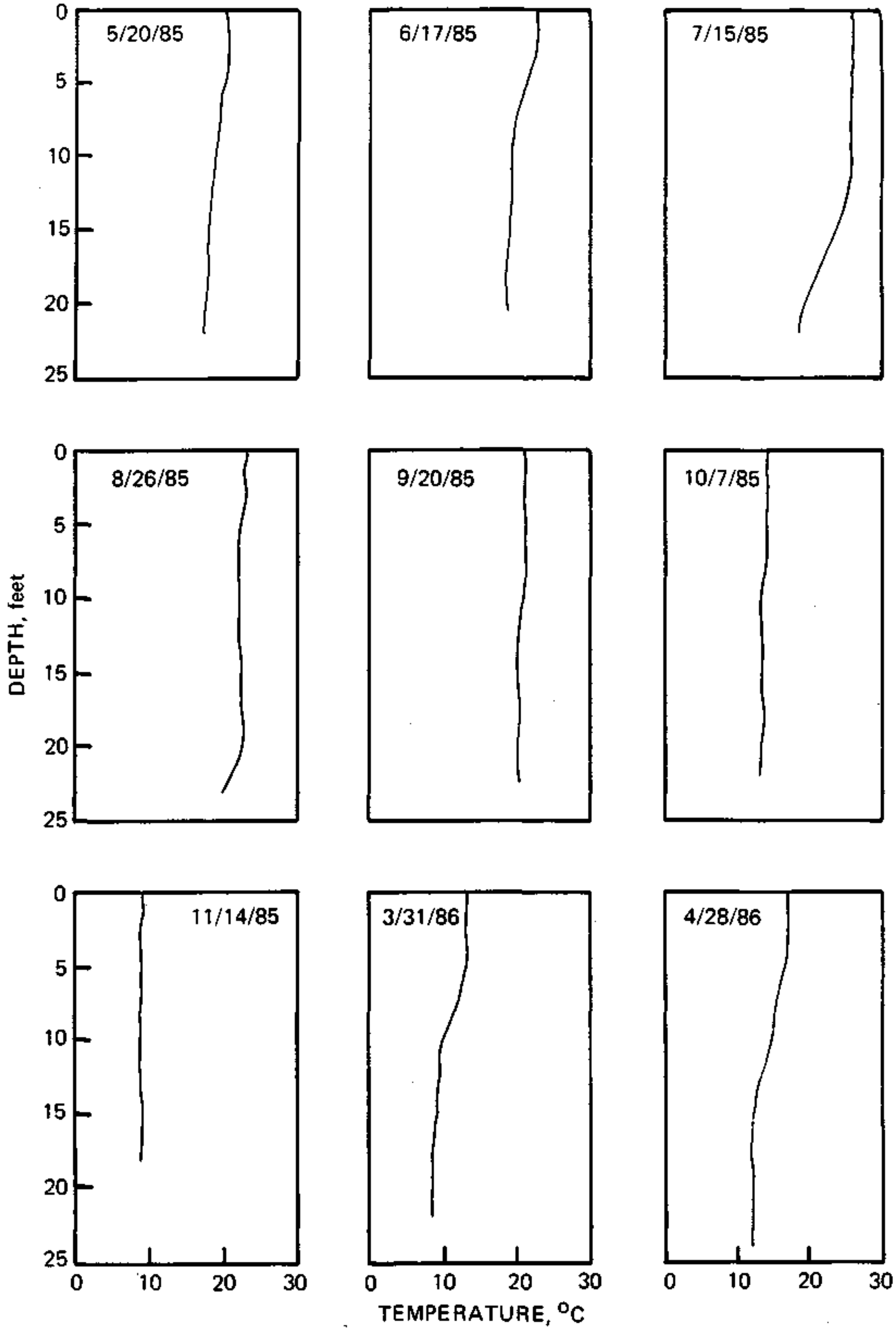

Figure 6. Temperature profiles for the deep station on selected dates

when the body is in a given state of stratification, and the center of gravity when the water body is isothermal. The greatest stability is generally reached just prior to maximum heat content in the summer. Detailed procedures for computing the stability factor for lakes by using periodic lake vertical temperature profiles are discussed by Symons (1969).

The temporal variations in the stability factor for Dawson Lake are shown in figure 7. The stability factor reached a maximum value of 9.84×10^6 foot-pounds (3.70 kilowatt-hours) on September 9, 1985. In comparison, stability values for Johnson Sauk Trail Lake reached a maximum of 3.86×10^6 foot-pounds (1.45 kilowatt-hours) on July 23, 1981. Dawson Lake is more than three times as large in volume as Johnson Sauk Trail Lake. The stability factors for Dawson and Johnson Sauk Trail Lakes were respectively 6700 and 8200 foot-pounds/acre-foot.

It is common knowledge that the impoundment of water alters its physical, chemical, and biological characteristics. The literature is replete with detailed reports on the effects of impoundments on various water quality parameters. The physical changes in the configuration of the water mass following impoundment reduce reaeration rates to a small fraction of those of free-flowing streams. Where the depth of impoundment is considerable, the thermal stratification acts as an effective barrier to wind-induced mixing of the hypolimnetic zone. The oxygen transfer to the deep waters is essentially confined to the molecular diffusion transport mechanism.

During the period of summer stagnation and increasing water temperatures, the bacterial decomposition of the bottom organic sediments exerts a high rate of oxygen demand on the overlying waters. When this rate of oxygen demand exceeds the oxygen replenishment by molecular diffusion, anaerobic conditions begin to prevail in the zones adjacent to the lake bottom. Hypolimnetic zones of man-made impoundments in Illinois were found to be anaerobic within a year of their formation (Kothandaraman and Evans, 1975).

The isopleths of dissolved oxygen for the Dawson Lake deep station are shown in figure 5. Selected vertical DO profiles for the deep station are shown in figure 8. Dissolved oxygen depletion in the near-bottom waters began to occur during the early part of May. As the summer thermal stagnation intensified, the anoxic zone of the hypolimnetic waters increased

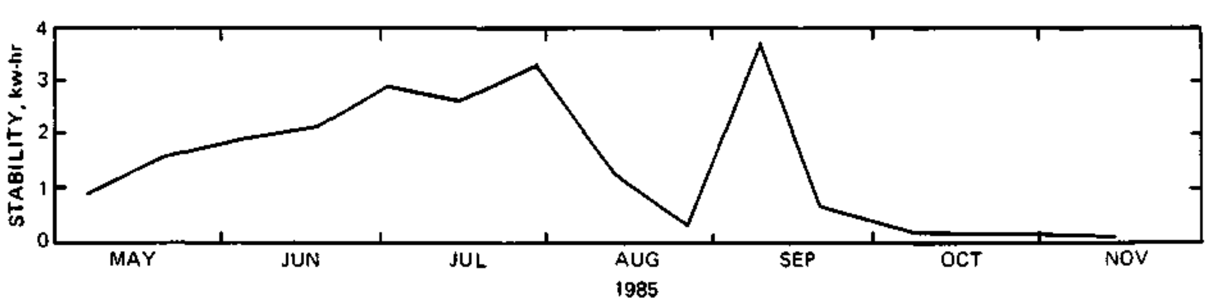

Figure 7. Temporal variations in lake stability

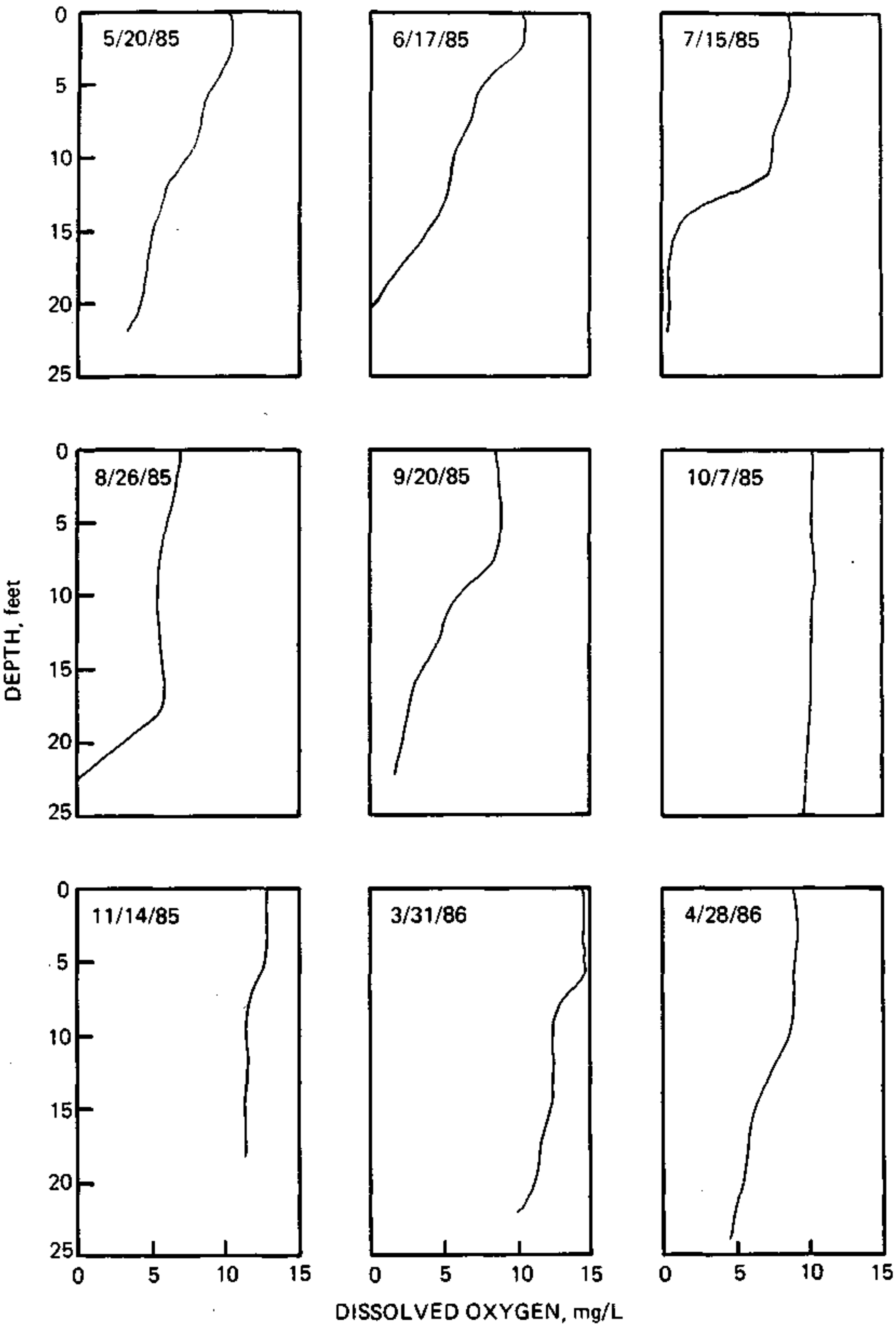

Figure 8. Dissolved oxygen profiles for the deep station on selected dates

progressively, reaching a maximum during mid-July. The extent of this anaerobic zone started diminishing thereafter, with the exception of a brief period around September 9, 1985, and the DO concentration became uniform in the water column in early October. As is apparent from figure 5, the progression of this anoxic zone coincided with the progression of the thermal stratification in the lake.

During the period of peak stratification, the lake was totally anoxic at depths 14 feet from the surface and below. About 239 acre-feet or approximately 16.2 percent of the water volume of the lake was anoxic, restricting the habitat for desirable fish food organisms and fish. In comparison, Johnson Sauk Trail Lake was totally anoxic at depths 8 feet from the surface and below, and about 38 percent of the lake volume was anoxic during the peak stratification period (Kothandaraman and Evans, 1983a).

Isothermal and iso-dissolved oxygen plots for the shallow station are shown in figure 9. A weak thermal gradient existed at the upper end of the lake during June and July. However, adequate oxygen concentrations were observed at this station during July and August. This is in contrast to the severe oxygen depletion observed at the shallow station in Johnson Sauk Trail Lake during July and August.

The dissolved oxygen and temperature data for the deep and shallow stations of Dawson Lake are shown respectively in appendices 1 and 2. The computed percent dissolved oxygen saturation values at the deep and shallow stations are included in appendices 3 and 4, respectively.

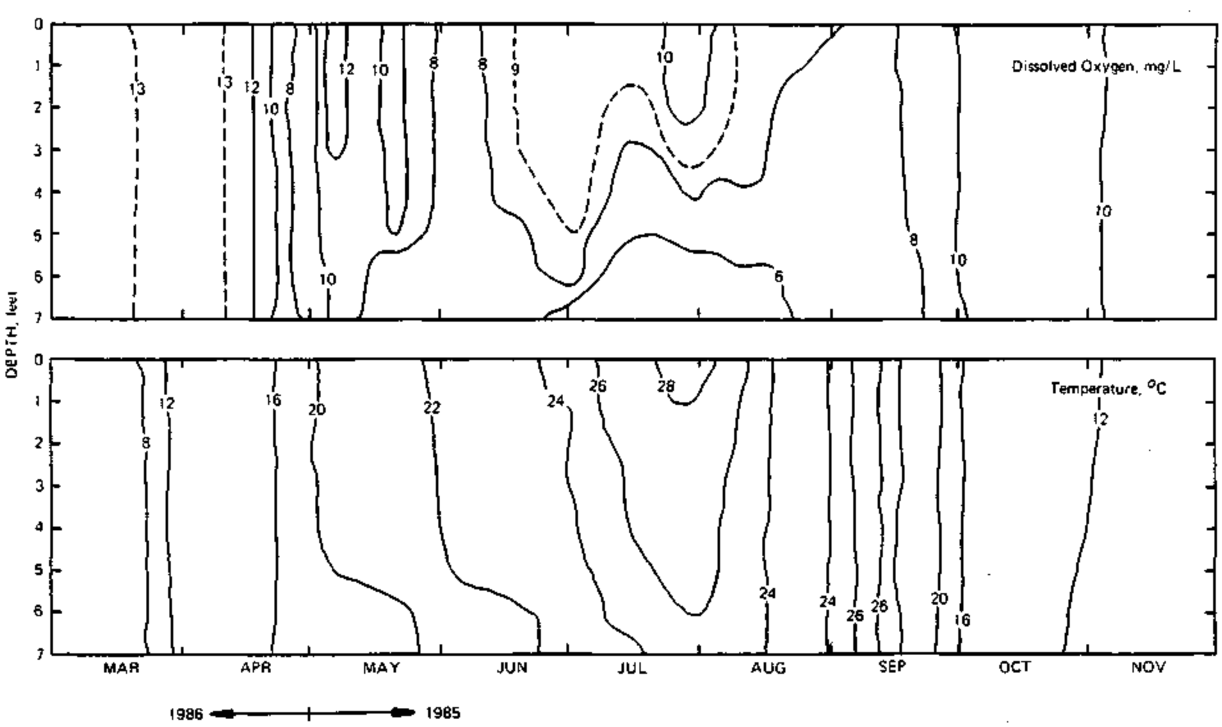

Figure 9. Isothermal and iso-dissolved oxygen plots for the shallow station

The surface saturation values at the deep station varied from 164.3 to 81.4 percent during the period of observation. The saturation values were generally very low at depths below 14 feet from the surface beginning in July and extending through mid-September. However, the saturation values at the shallow station of the lake were very satisfactory throughout the period of observation.

Secchi Disc Transparencies. Secchi disc visibility is a measure of lake water transparency or its ability to allow light transmission. Even though the secchi disc transparency is not an actual quantitative indication of light transmission, it serves as an index and a means of comparing similar bodies of water or the same body of water at different times. Since changes in water color and turbidity in a deep lake are generally caused by aquatic flora and fauna, transparency is often related to this entity.

The mean and range of values observed for secchi disc readings at the deep and shallow stations are given in table 10 along with summaries of observations for other physical and chemical water quality parameters. The temporal variations in secchi disc observations are shown in figures 10 and 13. The mean secchi disc readings were 30 inches at the deep station and 17 inches at the shallow station. Johnson Sauk Trail Lake exhibited a much higher mean and wider range of values at the deep station. The mean and range of values for Johnson Sauk Trail Lake in 1981 were 50 and 6 to 103 inches as compared with 30 and 14 to 62 inches for the deep station at Dawson Lake.

Turbidity. High turbidity affects the aesthetic quality of the water. Its origins are generally considered to be municipal and industrial wastes; clastic materials derived from the drainage basin; soil erosion resulting from agricultural practices and urban and highway development; sediments stirred by wind, waves, and high-speed boating activities in shallow lakes; and detrital remains of algae and aquatic and terrestrial plants and animals. However, in the case of Dawson Lake, some of these causative agents are absent, including industrial wastes, urban development, and high-speed boating activities.

Temporal variations of turbidity at surface, mid-depth, and near-bottom sampling points of the deep station are shown in figures 10, 11, and 12, respectively. Figure 13 depicts the characteristics at the shallow station. These values are summarized in table 10. The surface and mid-depth samples at the deep station had relatively low mean turbidity values of 14.1 and 15.3 NTU, respectively. Turbidity of the near-bottom water samples was higher, due partly to the settling of particulate matter from the surface and probably also due to some lake bottom disturbance during the sampling of near-bottom waters. The turbidity at the shallow station was more than double that of the surface samples at the deep station. This is primarily due to the resuspension of bottom sediments resulting from wind and boating activities.

Chemical Characteristics

pH and Alkalinity. It is generally considered that pH values above 8.0 in natural waters are produced by a photosynthetic rate that demands more

Table 10. Dawson Lake Water Quality Characteristics

Parameters	Deep Station: Near-surface Mean	Deep Station: Near-surface Range	Deep Station: Mid-depth Mean	Deep Station: Mid-depth Range	Deep Station: Near-bottom Mean	Deep Station: Near-bottom Range	Shallow Station: Near-surface Mean	Shallow Station: Near-surface Range
Secchi readings (inches)	30	14-62					17	3-31
Turbidity (NTU)	14.1	6.0-29.0	15.3	8.0-33.0	31.7	12.0-84.0	29.6	13.0-143.0
pH (dimensionless)		8.0-9.1		8.1-9.0		7.4-8.6		7.7-9.1
Alkalinity	126	89-157	128	100-157	143	111-179	134	112-165
Conductivity (µmho/cm)	337	251-421	339	253-418	357	272-441	350	263-432
Total phosphate-P	0.06	0.02-0.12	0.07	0.04-0.11	0.13	0.04-0.40	0.10	0.04-0.24
Dissolved phosphate-P	0.01	0.00-0.03	0.02	0.00-0.03	0.03	0.00-0.18	0.02	0.00-0.04
Total ammonia-N	0.10	0.03-0.23	0.15	0.01-0.34	0.71	0.07-2.16	0.17	0.01-0.47
Nitrate-N	2.03	0.11-5.89	2.06	0.09-6.54	1.53	0.04-4.22	2.35	0.06-5.42
Total Kjeldahl-N	1.04	0.53-1.67	0.97	0.32-1.65	1.64	0.47-3.17	1.21	0.70-1.84
Dissolved solids	253	204-358	257	216-354	261	204-346	256	204-338
Total suspended solids	15	7-26	15	7-30	34	13-106	30	12-124
Volatile suspended solids	7	2-18	7	2-18	9	2-22	9	4-19

Note: Values in mg/L unless otherwise indicated

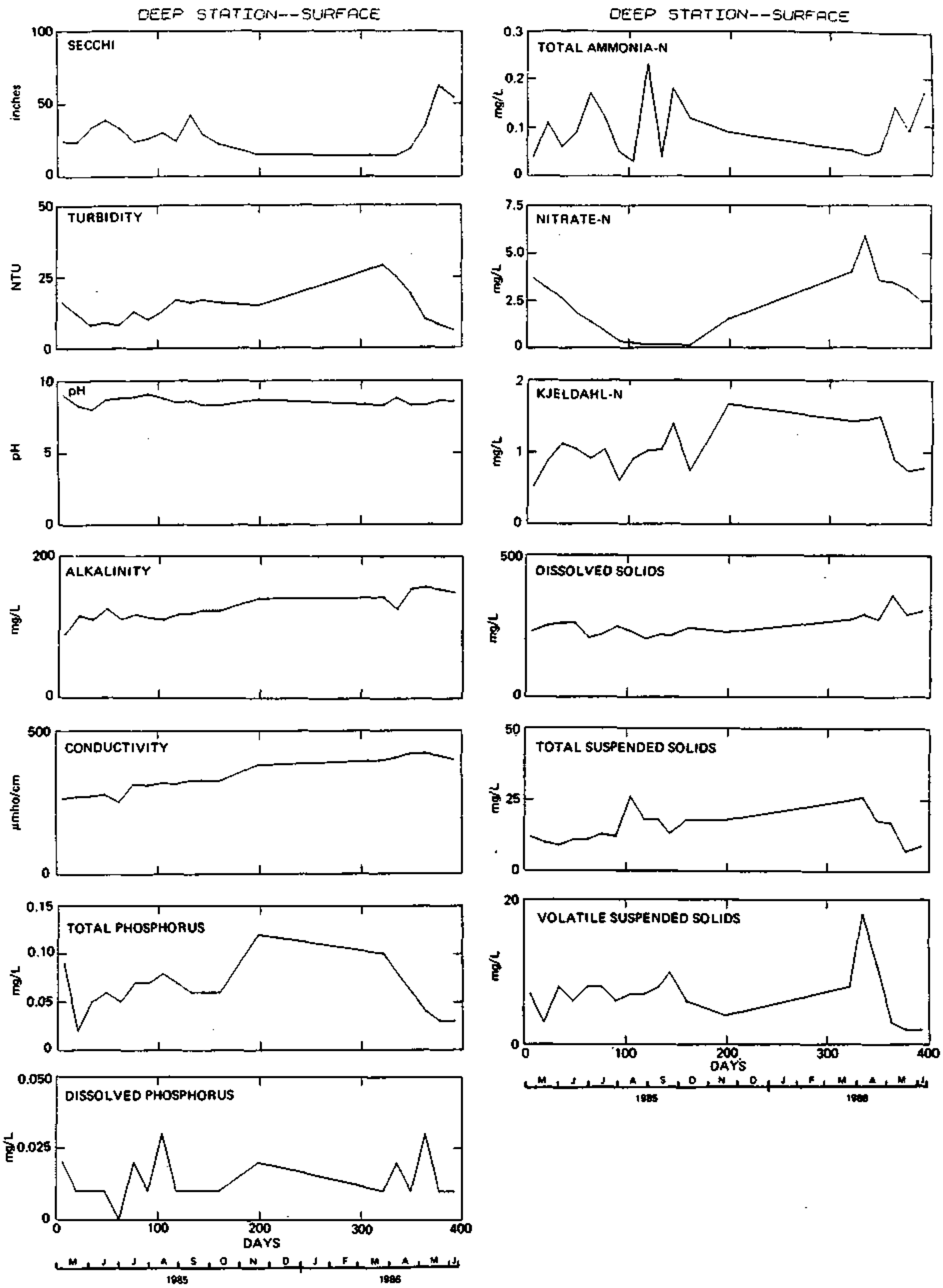

Figure 10. Temporal variations in surface water quality characteristics at the deep station

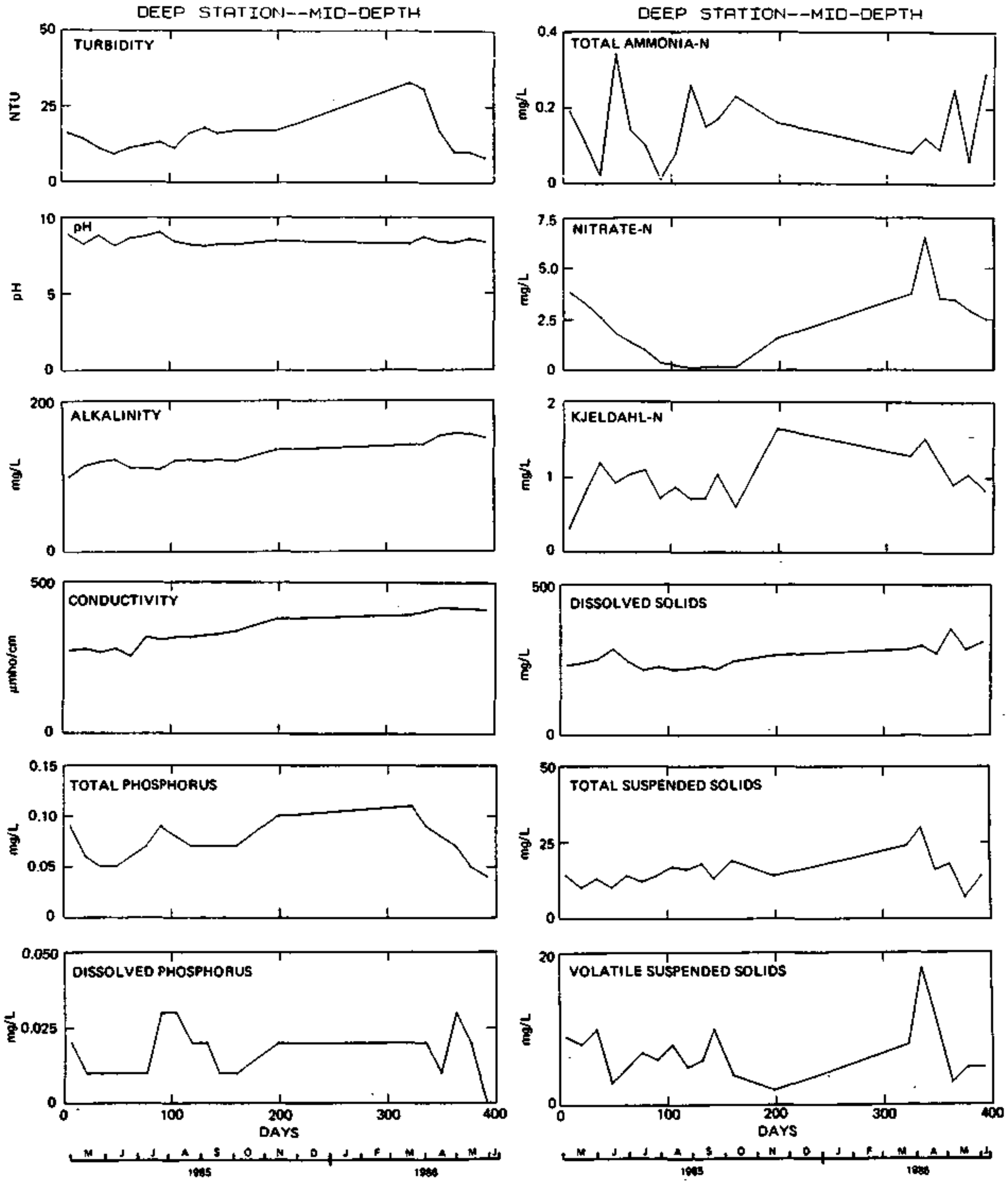

Figure 11. Temporal variations in mid-depth water quality characteristics at the deep station

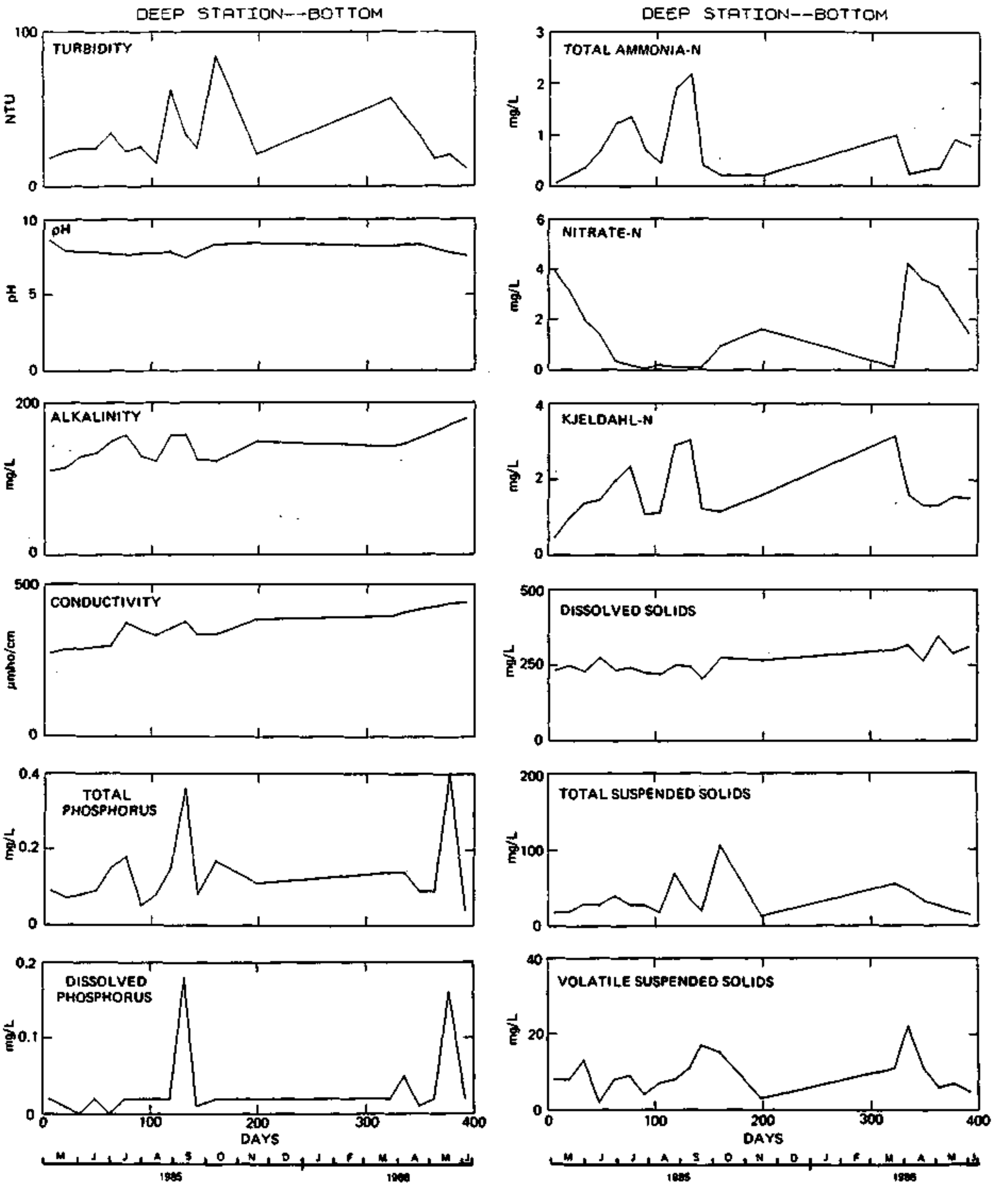

Figure 12. Temporal variations in near-bottom water quality characteristics at the deep station

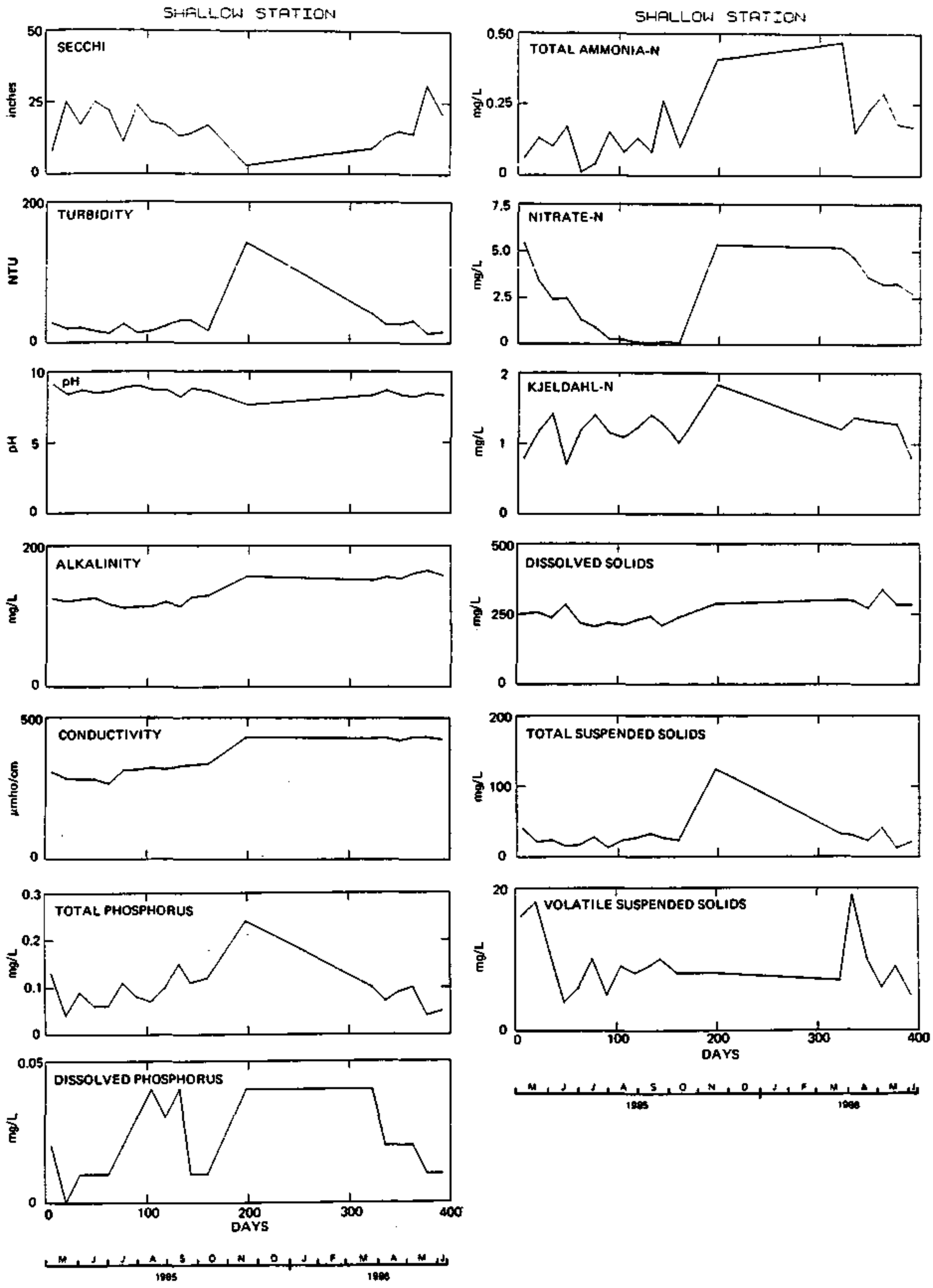

Figure 13. Temporal variations in water quality characteristics at the shallow station

carbon dioxide than the quantities furnished by respiration and decomposition (Mackenthun, 1969). Photosynthesis by aquatic plants uses carbon dioxide, removing it from bicarbonate, when no free carbon dioxide exists in the water medium. Decomposition and respiration tend to reduce pH and increase bicarbonates.

The alkalinity of a water is its capacity to accept protons and is generally imparted by bicarbonate, carbonate, and hydroxide components. The species makeup of alkalinity is a function of pH and mineral composition. The carbonate equilibrium, in which carbonate and bicarbonate ions and carbonic acid are in equilibrium, is the chemical system present in natural waters.

The pH and alkalinity values observed in Dawson Lake are typical of Illinois lakes. The range of pH values for the surface waters was 7.7-9.1, and the range for the near-bottom waters was 7.4-8.6. Alkalinity decreased in the surface water samples during summer months, presumably due to algal photosynthesis, and increased at the same time in the bottom water samples. Mean alkalinity values for the surface, mid-depth, and deep water samples were 126, 128, and 143 mg/1, respectively.

Conductivity. Specific conductance provides a measure of a water's capacity to convey electric current and is used as an estimate of the dissolved mineral quality of water. This property is related to the total concentration of ionized substances in water and the temperature at which the measurement is made. Specific conductance is affected by factors such as the nature of dissolved substances, their relative concentrations, and the ionic strength of the water sample. The geochemistry of the drainage basin is the major factor determining the chemical constituents in the waters. Practical applications of conductivity measurements include determination of the purity of distilled or deionized water, quick determination of the variations in dissolved mineral concentrations in water samples, and estimation of dissolved ionic matter in water samples.

The mean conductivity values at the deep station were 337 umho/cm for the surface, 339 umho/cm for the mid-depth, and 357 μmho/cm for the near-bottom samples. The conductivity of the shallow station samples was comparable to the conductivity of the near-bottom samples at the deep station. The increasing trend of conductivity toward the lake bottom follows the same pattern as for alkalinity. Conductivity of bottom waters was high during the summer months, indicating the increased mineralization of organic matter under anaerobic conditions. Lower conductivity values at the surface reflect biological uptake of dissolved minerals. The temporal variations of conductivity in the lake waters are shown in figures 10 through 13.

Phosphorus. Phosphorus as phosphate may occur in surface waters or ground waters as a result of leaching from minerals or ores, natural processes of degradation, or agricultural drainage. Phosphorus is an essential nutrient for plant and animal growth and, like nitrogen, it passes through cycles of decomposition and photosynthesis.

Because phosphorus is essential to the plant growth process, it has become the focus of attention in the entire eutrophication issue. With phosphorus being singled out as probably the most limiting nutrient and the one most easily controlled by removal techniques, various facets of phosphorus chemistry and biology have been extensively studied in the natural environment. To prevent biological nuisance, the Illinois Pollution Control Board (1986) stipulates, ". . .Phosphorus as P shall not exceed 0.05 mg/1 in any reservoir or lake with a surface area of 8.1 hectares (20 acres) or more or in any stream at the point where it enters any reservoir or lake."

In any river system, the two aspects of interest for phosphorus dynamics are the phosphorus concentration and phosphorus flux (concentration times flow rate) as functions of time and distance. The concentration itself indicates the possible limitation that this nutrient can place on vegetative growth in the stream. The phosphorus flux is a measure of phosphorus transport rate at any point in the river. This topic will be dealt with subsequently in the section on the nutrient budget for the lake.

Unlike nitrate-nitrogen, phosphorus applied as fertilizer is held tightly to the soil. Most of the phosphorus carried into streams and lakes from runoff over cropland will be in the particulate form. On the other hand, the major portion of phosphate-phosphorus emitted from municipal sewer systems is in a dissolved form. This is true of phosphorus generated from anaerobic degradation of organic matter in the lake bottom. Consequently, the form of phosphorus, namely particulate or dissolved, is indicative of its source to a certain extent.

From his experience with Wisconsin lakes, Sawyer (1952) concluded that aquatic blooms are likely to develop in lakes during summer months when concentrations of inorganic nitrogen and inorganic phosphorus are in excess of 0.3 and 0.01 mg/1, respectively. These critical levels for nitrogen and phosphorus concentrations have been accepted and widely quoted in scientific literature.

A summary of the observations for total and dissolved phosphate-phosphorus in the lake is given in table 10. Temporal variations in phosphorus content in the lake are depicted in figures 10 through 13. Even the lowest observed total phosphorus value was 2 to 4 times higher than the critical value suggested by Sawyer (1952). The mean dissolved phosphorus levels in the lake varied from 0.01 mg/1 at the surface to 0.03 mg/1 near the bottom. The total and dissolved phosphorus levels in the lake on April 14, 1986, after the spring turnover, were 0.08 and 0.01 mg/1, respectively. A progressive increase in phosphorus content in the deep waters of the lake was noted during the summer months (figure 12), until the onset of fall turnover. The highest total phosphorus level measured in the lake was 0.40 mg/1. This occurred in the near-bottom waters on May 12, 1986.

The ratio of dissolved phosphorus to total phosphorus in the surface water samples varied from 0.00 to 0.57 with a mean value of 0.22. The ratio of dissolved phosphorus to total phosphorus at mid-depth varied from 0.00 to 0.43 with a mean of 0.22 for the duration of the lake monitoring. Corresponding values for the near-bottom waters at the deep station were 0.00 to 0.50 and 0.22. Unlike the case of Johnson Sauk Trail Lake, the phosphorus ratio mean values were the same (0.22) for the surface, mid-depth, and deep sampling points in Dawson Lake. These values for Johnson Sauk Trail Lake were respectively 0.35, 0.36, and 0.50.

Nitrogen. Nitrogen in natural waters is generally found in the form of nitrate, organic nitrogen, and ammonia-nitrogen. Nitrates are the end product of the aerobic stabilization of organic nitrogen, and as such they occur in polluted waters that have undergone self-purification or aerobic treatment processes. Nitrates also occur in percolating ground waters. Ammonia-nitrogen, being a constituent of the complex nitrogen cycle, results from the decomposition of nitrogenous organic matter. Ammonia-nitrogen can also result from municipal and industrial waste discharges to streams and rivers.

The concerns about nitrogen as a contaminant in water bodies are twofold. First, because of adverse physiological effects on infants and because the traditional water treatment processes have no effect on the removal of nitrate, concentrations of nitrate plus nitrite as nitrogen are limited to 10 mg/1 in public water supplies. Second, a concentration in excess of 0.3 mg/1 is considered sufficient to stimulate nuisance algal blooms (Sawyer, 1952). The IPCB stipulates that ammonia-nitrogen and nitrate plus nitrite as nitrogen should not exceed 1.5 and 10.0 mg/1, respectively.

Nitrogen is one of the principal elemental constituents of amino acids, peptide, proteins, urea, and other organic matter. Various forms of nitrogen -- for example, dissolved organic nitrogen and inorganic nitrogen such as ammonium, nitrate, nitrite, and elemental nitrogen -- cannot be used to the same extent by different groups of aquatic plants and algae.

Vollenweider (1968) reports that in laboratory tests, the two inorganic forms of ammonia and nitrate are as a general rule used by planktonic algae to roughly the same extent. However, Wang et al. (1973) reported that during periods of maximum algal growth under laboratory conditions, ammonium-nitrogen was the source of nitrogen preferred by planktons. In the case of higher initial concentrations of ammonium salts, yields were noted to be lower than with equivalent concentrations of nitrates (Vollenweider, 1968). This was attributed to the toxic effects of ammonium salts. The use of nitrogenous organic compounds has been noted by several investigators, according to Hutchinson (1957). However, Vollenweider (1968) cautions that the direct use of organic nitrogen by planktons has not been definitely established, citing that not one of 12 amino acids tested with green algae and diatoms was a source of nitrogen when bacteria-free cultures were used. But the amino acids were completely used up after a few days when the cultures were inoculated with a mixture of bacteria isolated from water. Vollenweider has opined that because there are always bacterial fauna active in nature, the question of the use of organic nitrogen sources is of more interest to physiology than to ecology.

The mean and range of values for ammonia-nitrogen, nitrate-nitrogen, and Kjehdal-nitrogen in the lake are included in table 10, and the temporal variations in these parameters are shown in figures 10 through 13. Mean total inorganic nitrogen (total ammonia-nitrogen and nitrate-nitrogen) was always higher than the suggested critical concentration (0.3) for nitrogen. The mean values for total ammonia-nitrogen increased from 0.10 mg/1 at the surface to 0.71 mg/1 at the bottom of the deep station. Nitrate-nitrogen mean values were 2.03 mg/1 at the surface, 2.06 mg/1 at mid-depth, and 1.53 mg/1 at the bottom of the deep station. Kjeldahl-nitrogen mean values were much higher near the bottom of the lake.

Significant decreases in nitrate-nitrogen concentrations were detected throughout the lake during summer months. Ammonia-nitrogen and Kjeldahl-nitrogen concentrations increased at the mid-depth and the deep sampling points during the summer thermal stagnation period. This is an indication of the anaerobic decomposition of the organic debris occurring on the lake bottom.

Total Solids. Total Dissolved Solids. and Suspended Solids. Total solids, as presented here, include total dissolved solids and suspended solids. In natural waters, the dissolved solids consist mainly of carbonates, bicarbonates, sulfates, chlorides, phosphates, and nitrates of calcium, magnesium, sodium, and potassium with traces of iron, manganese, and other substances. The constituent composition of these minerals is to a large extent dependent on the geochemistry of the area contributing to the surface or ground-water resource. The amount of suspended solids found in impounded waters is small compared with the amount found in streams because solids tend to settle to the bottom in lakes. However, in shallow lakes this phenomenon is greatly modified by wind and wave actions and by the type and intensity of use to which these lakes are subjected.

All salts in solution change the physical and chemical nature of the water and exert an osmotic pressure. Some have physiological as well as toxic effects. However, possible synergistic or antagonistic interactions between mixed salts in solution may cause the effects of salts in combination to be different from those of salts occurring separately.

Greeson (1971) observed that high dissolved solids contents of Oneida Lake (New York) in 1967 and 1969 accompanied the high production of algae. Low dissolved solids content in 1968 accompanied lesser algal production. He concluded that these relationships indicate that the dissolved solids content is an important index of potential productivity conditions because no element, ion, or compound is likely to be a limiting factor on algal production when the dissolved solids content is high.

Dissolved solids concentrations found in Dawson Lake are typical of midwestern lakes. The mean dissolved solids values were nearly the same throughout the lake. The volatile (organic) fraction of the suspended sediments in the surface and mid-depth samples at the deep station were higher (47 percent) than in the near-bottom samples (26 percent) and at the shallow station (30 percent). High suspended sediment values reported for the lake near-bottom samples may be due partly to the accidental lake bottom disturbance while sampling with a Kemmerer sampler, and partly to the settling of particulate matter from the water column. The results for solids determinations are shown in table 10 and in figures 10 through 13.

All the observed physical and chemical data for the lake stations are included in appendices 5A, 5B, 5C, and 6.

Biological Characteristics

Algae. The total algal counts and the species distribution of algae found in the lake are shown in table 11. Chlorophyll-a data are also included in the table. Except for the observations on May 6 and July 15, 1985, the total algal counts in the lake at the deep station were found to be well below densities considered to be of bloom proportion (≥ 500 counts/ml). Blue-green algae were the dominant species only once at the shallow station and three times at the deep station. However, blue-green

Table 11. Algal Types and Densities and Chlorophyll-a
in Dawson Lake
(Algal densities in counts per milliliter)

Shallow Station

Date	BG	G	D	F	0	Total	Chlorophyll-a (ug/1)
5/6/85		1360	500	650		2510	68.0
5/20/85							50.0
6/3/85							37.0
6/17/85		110	30	10		150	19.4
7/1/85	40	60			10	110	26.4
7/15/85		1180		1280		2460	73.2
7/29/85	170			250		420	47.1
8/12/85	180	110	30			320	35.9
8/26/85	130	150		10		280	36.1
9/9/85	40	220		30		290	39.7
9/20/85		390	40	260		690	
10/7/85		110	20			130	

Deep Station

Date	BG	G	D	F	O	Total	Chlorophyll-a (ug/1)
5/6/85		400	370	1630		2400	51.0
5/20/85							62.0
6/3/85							48.5
6/17/85		160	5	5	10	180	22.2
7/1/85	160	140		20		320	27.6
7/15/85	2590			40		2630	52.3
7/29/85	200	50		40		290	30.8
8/12/85	170	30				200	39.8
8/26/85		400		50		450	30.2
9/9/85	110	370				480	38.3
9/20/85		60	120			180	
10/7/85		180				180	

Note: BG = blue-greens; G = greens; D = diatoms; F = flagellates; 0 = others algae were found to be of bloom proportion only once: on July 15, 1985 at the deep station. Blue-green algae blooms generally create unsightly conditions by forming algal scum under quiescent lake conditions. Nuisance algal blooms were never observed in the lake during the period of monitoring. This is in sharp contrast to the conditions observed in Johnson Sauk Trail Lake, where algal densities as high as 21,955 cts/ml, with blue-green algae dominant during the summer months, were reported (Kothandaraman and Evans, 1983a).

The highest chlorophyll-a concentration measured in the deep-station samples from Dawson Lake was 62.0 µg/1 (table 11). The concentration was 52.3 on July 15, 1985 when the highest algal density, with blue-green dominance, was observed. There is apparently no correlation between chlorophyll-a and the algal densities found in Dawson Lake.

Benthic Organisms. The types and densities of benthic macroinvertebrate communities in the lake sediments are given in table 12. *Chaoborus* and Chironomidae were the dominant species found in the lake and were the only two species found at the deep station. The overall averages of the macroinvertebrate densities were 1115 and 1260 counts/m^2 for the shallow and deep stations.

The densities of benthic organisms found in Dawson Lake are much less than those for Johnson Sauk Trail Lake. The reported densities for the shallow and deep stations in Johnson Sauk Trail Lake were respectively 3140 and 6350 counts/m^2 (Kothandaraman and Evans, 1983a). Unlike in Johnson Sauk Trail Lake, the average benthos densities for the deep and shallow stations were similar in Dawson Lake.

Bacterial Densities. Bacterial densities found in the lake and in the tributary (North Fork Salt Creek) upstream and downstream of the lake are

Table 12. Benthic Macroinvertebrates Collected from Dawson Lake (Individuals per square meter)

Taxa	6/3/85	7/15/85	8/12/85	9/20/85
	Shallow Station			
Cerotopogonidae (biting midge)		38		
Chaoborus (phantom midge fly)		134	875	689
Chironomidae (midge fly)	144	344	115	1,622
Tubificidae (sludge worm)		383		
Total	144	899	990	2,311
	Deep Station			
Chaoborus	617	1,416	72	
Chironomidae	345	727	517	86
Total	962	2,143	589	86

shown in table 13. The general use water quality standard in Illinois for fecal coliform is: "Based on a minimum of five samples taken over not more than a 30 day period, fecal coliform shall not exceed a geometric mean of 200 per 100 ml, nor shall more than 10% of the samples during any 30 day period exceed 400 per 100 ml" (Illinois Pollution Control Board, 1986).

Since the bacterial samples were collected on a biweekly basis only, no attempt was made to estimate the geometric mean of the fecal coliform densities in the lake or its tributary. It is seen from the table that North Fork Salt Creek had fecal coliform densities higher than 400 per 100 ml during summer months (June through September) upstream of the lake and had much smaller values downstream of the lake. The bacterial densities in the lake samples were generally low. The fecal coliform count exceeded 400 per 100 ml on only one of 12 occasions at the shallow station, and on three occasions at the deep station.

Macrophvtes. Aquatic vegetation is found in most lakes and is beneficial to the natural ecosystem. It provides food and cover for aquatic organisms, provides oxygen, and stabilizes bottom sediments. However, excessive vegetation generally interferes with recreational activities, adversely affects aquatic life, and destroys aesthetic values to the extent of decreasing the economic values of properties surrounding a lake. Under these circumstances, aquatic plants are often referred to as weeds.

The areal extent and types of vegetation found in Dawson Lake are shown in figures 14a and 14b. Macrophytes covered a total area of 10.1 acres constituting 6.7 percent of the total lake surface.

Since 1981 the Department of Conservation has had an on-going management scheme of lake drawdown from October to March of every other year (1981, 1983, and so on). This practice freezes out the root systems and

Table 13. Fecal Coliform Densities in Dawson Lake
and Its Tributary
(Counts per 100 milliliters)

Date. 1985	Upstream	Shallow lake	Deep lake	Downstream
5/6	173	12	32	20
5/20	58	11	84	27
6/3	487	134	11	201
6/17	440	88	12	56
7/1	750	20	3	38
7/15	TNC*	535	500	360
7/29	3,920	267	745	no flow
8/13	no flow	148	20	no flow
8/26	1,087	2	297	no flow
9/9	9,067	87	530	no flow
9/20	no flow	116	47	no flow
10/7	no flow	2	0	1

* Too numerous to count

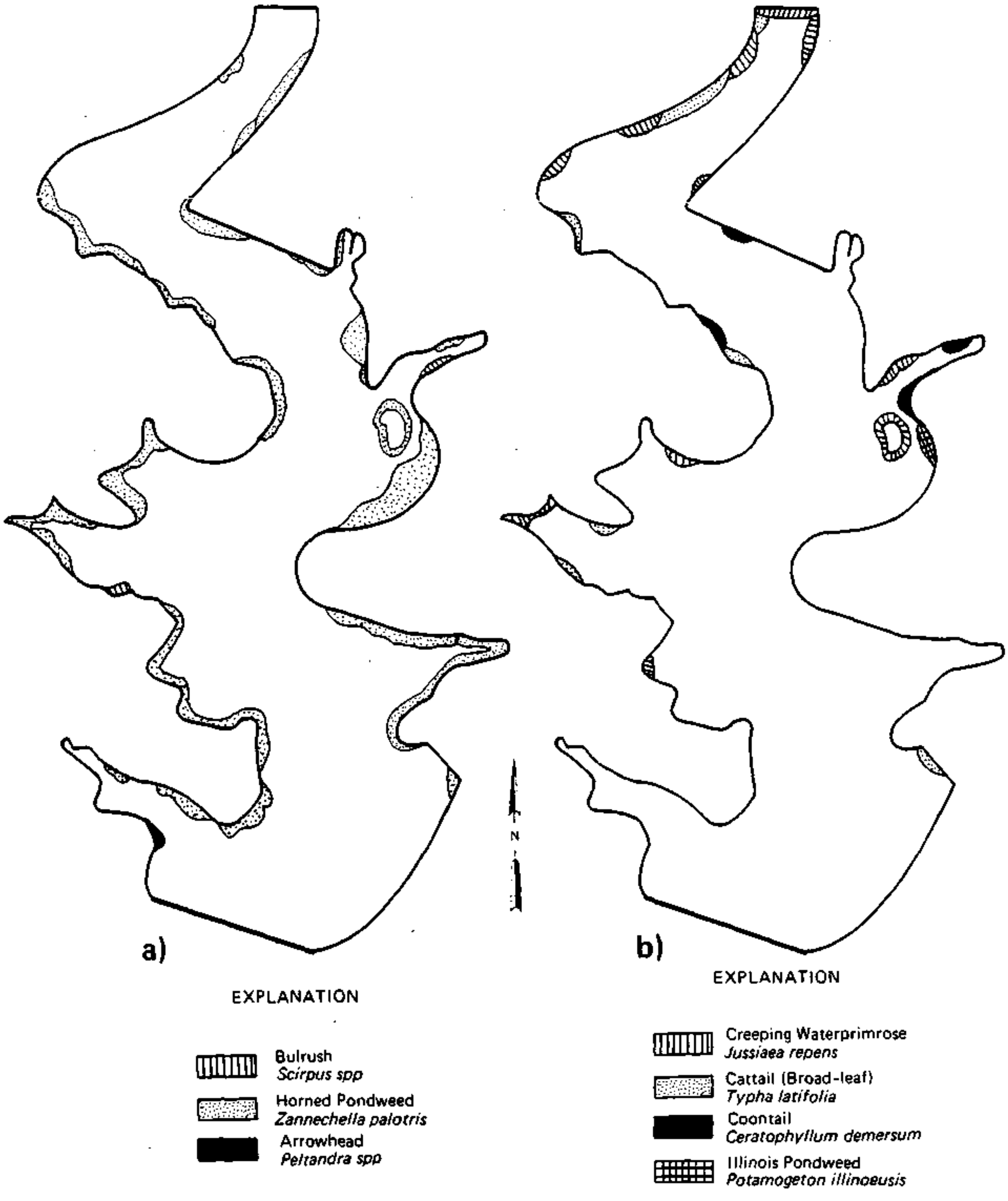

Figure 14. Types and areal extent of macrophytes

seeds of macrophytes and also results in compaction of the exposed sediments. This practice, no doubt, has kept the macrophyte growths in the littoral zone under control, even though the lake is highly eutrophic.

In contrast, Johnson Sauk Trail Lake had a very dense growth covering about 26.8 percent of the lake surface (Kothandaraman and Evans, 1983a). Macrophyte growths in Dawson Lake were much less dense than in Johnson Sauk Trail Lake and did not appear to interfere with potential uses of the lake. As a matter of fact, these macrophytes appear to provide a well-balanced habitat for the fish.

There were four species of submergent vegetation found in the lake along with very small patches of three types of emersed rooted vegetation: cattail, bulrush, and arrowhead. Horned pondweed was the dominant species observed in the lake.

Sediment Characteristics

Sedimentation in the Lake

Most midwestern streams transport a considerable amount of soil particles, especially during storm events. These sediments in transport are fine-sized particles, generally smaller than 60 µm, and consist mainly of silt and clay. When streams discharge into impoundments, about 90 percent of the sediment conveyed by streamwaters is trapped in the impoundment. It is reported that the median rate of loss of reservoir volume due to sediment is 0.6 percent per year in Illinois (Roseboom et al., 1978). The highest and lowest sedimentation rates measured by the State Water Survey in 101 reservoirs are 5.67 and 0.15 percent per year, respectively. In Illinois, the soil delivery to reservoirs from erosion varies from 1.3 to 2.3 tons per acre per year. Sediments, in addition to causing a loss of storage capacity, are instrumental in nutrient recycling and are potential sources of contaminants such as heavy metals and organic pesticides.

Nine transects, shown in figure 2, were established and demarcated by permanent concrete survey monuments. Soundings for water depth and sediment thickness were made from a boat by using a taut line along the transect sections at selected intervals. A spud bar was used to ascertain the depth of the original lake bottom. Figure 15 shows the cross sections of the lake at two selected transects. The original lake bottom is shown by a dotted line and the present lake bottom by a solid line. The difference in elevation between the two lines is the extent of sediment accumulation in the lake since its inception. The depth-area-volume relationships for Dawson Lake are shown in figure 16.

On the basis of the sediment survey, it was determined that the storage capacity of the lake has been reduced from an original volume of 1619 acre-feet to 1475 acre-feet. This represents a loss in water storage of 8.8 percent in 22.5 years, or 0.40 percent per year. This rate of loss of capacity is slightly below the median rate observed in Illinois lakes and reservoirs. The upper end of the lake and the original channel section within the impoundment show the greatest degree of siltation. The average sediment density used for each lake segment in determining the sediment

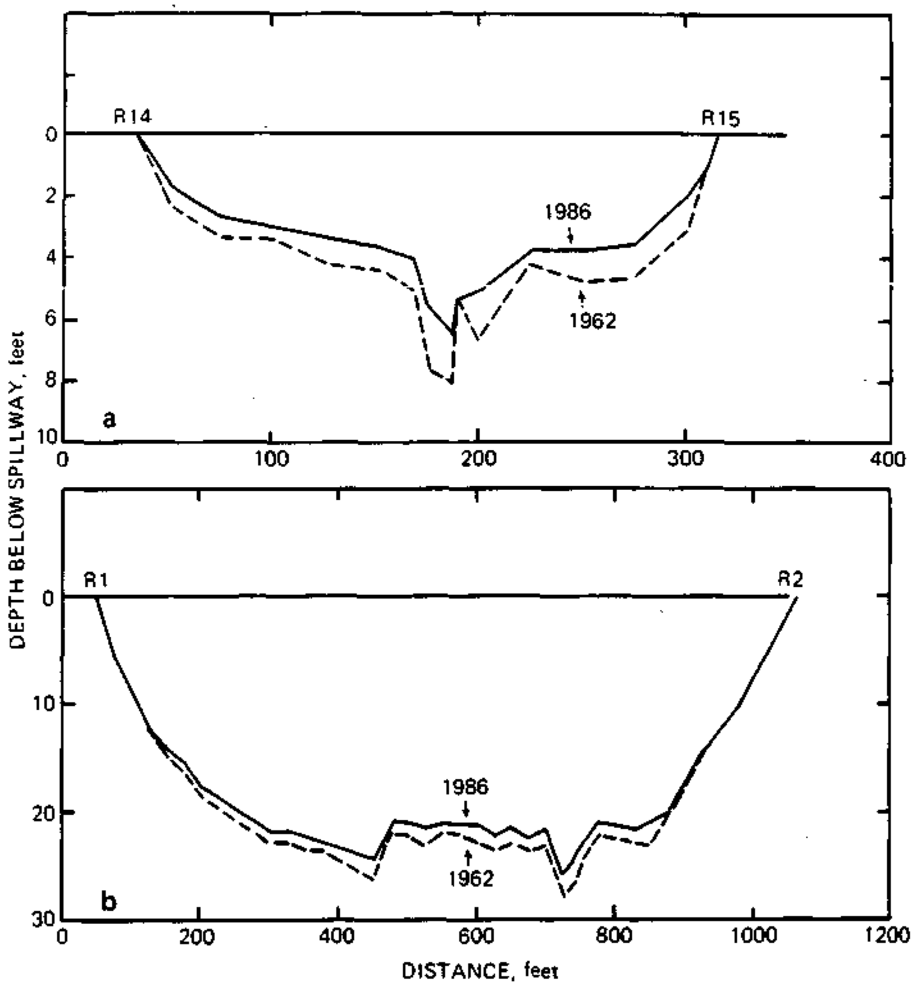

Figure 15. Reservoir cross sections at two selected transects

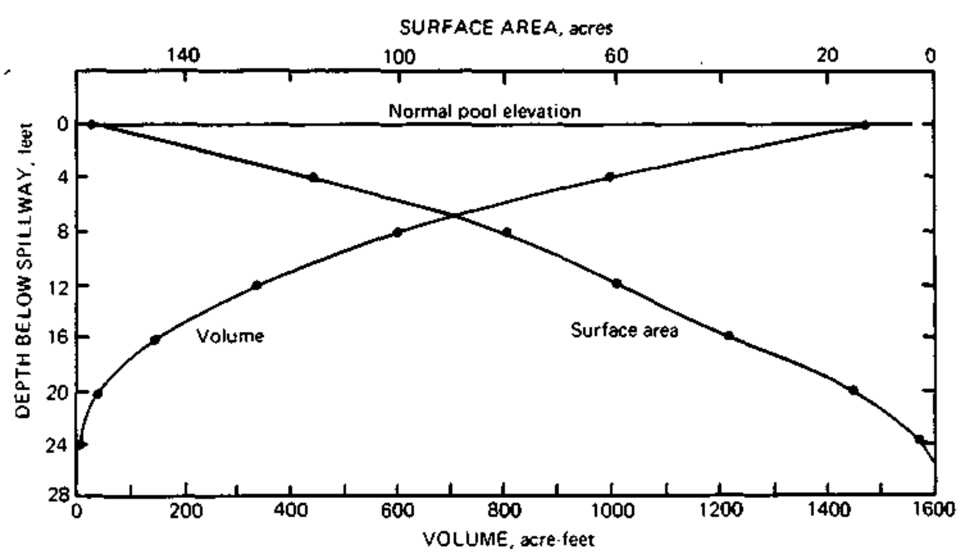

Figure 16. Depth-area-volume relationships for Dawson Lake

tonnage can be found elsewhere (Fitzpatrick, 1987). The estimated soil loss on the watershed is 2.60 tons per acre per year. This is within the range of values observed in other lakes in Illinois. A summary of the sediment survey is given in table 14.

Surficial Sediments

Sediment Oxygen Demand Rates. Results of in-situ measurements of sediment oxygen demand rates are shown in table 15. Measurements were made at the shallow and deep stations during the period of thermal stratification on July 15, 1985.

In addition to the ambient water temperatures and observed sediment oxygen demand rates at the ambient water temperature levels, rates of sediment oxygen demand at 20 and 25°C were computed and are shown in this table for comparative purposes. The following equation was used:

Table 14. Summary of Sedimentation Data, Dawson Lake

Date lake was formed	1963
Date of lake sedimentation survey	1986
Time interval, years	22.5
Average depth, feet	
1962	10.2
1986	9.3
Surface area at spillway level, acres	150
Storage capacity at spillway level, acre-feet	
1962	1,619
1986	1,475
Loss of storage capacity	
Volume, acre-feet	144
Percent	8.8
Rate of loss of storage capacity	
Acre-feet per year	6.4
Percent per year	0.4
Sedimentation	
Total, tons	167,300
Rate, tons per year	7,436
Watershed sediment delivery rate, tons per acre per year	2.7

Table 15. In-situ Sediment Oxygen Demand Rates in Dawson Lake

Location	Water depth (feet)	Ambient temperature T (°C)	SOD (g/m^2/day) At T°C	At 25°C	At 20°C
Shallow station	8	25.8	1.03	1.01	0.81
Deep station	23	25.9	1.63	1.56	1.24

$$SOD_T = SOD_{20} \ (1.047^{T-20})$$

where

SOD_T = sediment oxygen demand at any temperature, T°C
SOD_{20} = sediment oxygen demand at 20°C

Data on benthic organisms, algae, and sediment consistency obtained concomitantly with SOD measurements are shown in table 16.

The sediment oxygen demand rates observed in Dawson Lake are very low compared to the values observed for other lakes in Illinois. These values are in the very low end of the spectrum of values ranging from 1.66 $g/m^2/day$ in Lake Eureka to 31.57 $g/m^2/day$ in Pistakee Bay at 25°C, determined by the Water Quality Section of the Illinois State Water Survey.

Sediment Consistency. Results of analyses of Ekman dredge samples for moisture content and volatile fractions are given in table 17. The sediments at the deep station were fluffier and capable of holding more water than the sediments obtained from the shallow station. Also the volatile fraction of the sediments was higher at the deep station than at the shallow station. On an average, shallow station samples were 43.3 percent dry solids (56.7 percent moisture content) with 7.4 percent volatile solids (92.6 percent fixed solids). Deep-station samples were 33.4 percent dry solids (66.6 percent moisture content) with 8.9 percent volatile solids (91.1 percent fixed solids).

Dry solids in Lake Eureka and Lake Canton, which are also man-made lakes, were reported to vary from 26.0 to 53.7 percent (Roseboom et al., 1979). Volatile solids fractions ranged from 6.0 to 10.0 percent. The values observed for Dawson Lake appear to be typical of other man-made lakes in Illinois.

Table 16. Physical and Biological Data for SOD Measurement Dates

Location	Benthic organisms (cts/ml)	Algae (cts/ml)	Sediments % dry	Sediments % volatile
Shallow station	899	2,460	41.5	7.8
Deep station	2143	2,630	33.8	8.7

Table 17. Consistency of Surficial Sediments

Date	Shallow station % dry	Shallow station % volatile	Deep station % dry	Deep station % volatile
7/15/85	41.5	7.8	33.8	8.7
8/26/86	39.8	7.2	34.5	9.2
9/20/85	48.9	7.1	32.0	8.7

Inflows and Outflows

A water budget for the lake was developed for the months May to July 1985, taking into account the tributary flows upstream and downstream of the lake, direct precipitation falling on the lake, and lake evaporation. The general expression for the hydraulic budget of a lake is:

$$\Delta S = P + I + U - E - O$$

where

ΔS = change in storage
P = precipitation on lake surface
I = inflow from surface stream
U = subsurface inflow through the lake bottom
E = evaporation
0 = outflow through surface outlet

Stream staff gages were installed in North Fork Salt Creek upstream and downstream of the lake with the intent of developing a daily record of stream stages. This effort was thwarted by frequent vandalism of the gages, changes in the park personnel assigned the task of making the daily observations, and the lake drawdown which occurred beginning on October 7, 1985. The lake was allowed to fill back to normal pool level during the early spring of 1986. For these reasons, reliable data on streamflows could be gathered only for the first three months of the project: May, June, and July 1985.

Table 18 shows the monthly precipitation data for Dawson Lake (estimated from published data) and for the U.S. Weather Bureau stations at' the Bloomington waterworks and Normal. Both these weather stations are within 20 miles of the project site. Lake evaporation losses shown in table 18 were calculated on the basis of values suggested by Roberts and Stall (1967).

Monthly water budgets for the lake are shown in table 19. All the values are expressed in cubic feet per second. Tributary inflow into the lake and the outflow from the impoundment are the monthly averages of flow values obtained from daily single observations of stage gages. Precipitation and evaporation values in inches for the respective months were converted to flow rates in cubic feet per second on the basis of a lake surface area of 150 acres. The last column in the table shows inflow minus outflow. The month-to-month change in lake storage during the period covered in table 19 was insignificant.

Of the three months for which the water budget for the lake was evaluated, outflow from the lake exceeded the inflow during two months. Assuming the change in lake levels to be zero or negligible, the last column in the table provides an estimate of the influence of the ground-water source. The hydraulic retention time of the lake is 1.98 years at an annual mean tributary flow of 1.03 cfs. The highest tributary flow measured was 5.11 cfs on July 15, 1985. At this rate of flow, the hydraulic retention time would be 0.40 year.

Table 18. Precipitation in Dawson Lake Watershed and Its Vicinity, and Lake Evaporation

Period	Precipitation (inches) Bloomington	Normal	Dawson Lake	Evaporation (inches)
May 1985	3.90	3.62	3.76	4.20
June	4.41	4.68	4.54	5.00
July	4.86	5.63	5.25	5.55
August	4.52	4.48	4.50	4.80
September	2.07	2.08	2.07	3.25
October	3.02	4.50	3.56	2.00
November	8.79	9.33	9.06	0.90
December	2.44	2.50	2.47	0.40
January 1986	0.13	0.12	0.13	0.35
February	2.19	2.09	2.14	0.60
March	1.10	1.12	1.11	1.40
April	1.39	1.31	1.35	2.80

Table 19. Monthly Water Budgets for Dawson Lake

Month. 1985	Inflow (cfs) North Fork Salt Creek	Precipitation	Outflow (cfs) North Fork Salt Creek	Evaporation	Inflow minus outflow
May	0.56	0.76	1.61	0.85	-1.14
June	1.04	0.92	0.75	1.02	+0.18
July	1.39	1.07	1.45	1.13	-0.12

Nutrient Budget

Although nitrogen and phosphorus are not the only nutrients required for algal growth, they are generally considered to be the two main nutrients involved in the lake eutrophication process. Despite the controversy over the role of carbon as a limiting nutrient, a vast majority of researchers regard phosphorus as the most frequently limiting nutrient in lakes.

Several factors have complicated attempts to quantify the relationship between lake trophic status and measured concentrations of nutrients in lake waters. For example, measured inorganic nutrient concentrations do not denote nutrient availability, but merely represent what is left over by the lake production process. A certain fraction of the nutrients (particularly phosphorus) becomes refractory while passing through successive biological cycles. In addition, numerous morphometric and chemical factors affect the availability of nutrients in lakes. Factors such as mean depth, basin shape, and detention time affect the amount of nutrients a lake can absorb without nuisance conditions. Nutrient budget calculations represent the first step in quantifying the dependence of lake water quality on the nutrient supply. It is often essential to quantify nutrients from various sources from the viewpoint of management and eutrophication control.

A potential source of nitrogen and phosphorus for lakes is the watershed drainage, which can include agricultural runoff, urban runoff, swamp and forest runoff, domestic and industrial waste discharges, septic tank discharges from lakeshore developments, precipitation on the lake surface, dry fallout (i.e., leaves, dust, seeds, and pollen), ground-water influxes, nitrogen fixation, sediment recycling, and aquatic bird and animal wastes. Potential sinks can include outlet losses, fish catches, aquatic plant removal, denitrification, ground-water recharge, and sediment losses.

The sources of nutrients considered for Dawson Lake were tributary inputs, direct precipitation on the lake surface, internal nutrient recycling from bottom sediments under anaerobic conditions, and the point source waste discharge from the state park water treatment facility. The discharge of nutrients from the lake through North Fork Salt Creek was the only sink readily quantifiable.

The flow weighted-average method of computing nutrient transport by a tributary was used in estimating the phosphorus and nitrogen loads delivered by the tributary. A summary of water quality characteristics observed for North Fork Salt Creek is shown in table 20. The raw data are included in appendices 7 and 8. The mean and range of values for 19 individual observations for turbidity and various fractions of nitrogen, phosphorus, and solids content are shown in the table. Each individual observation for nitrogen and phosphorus concentrations in the tributary sample was used along with the mean flow values for the period represented by that sample to compute the nutrient transport for the given period. The total amount of any specific nutrient transported by the creek is then given by the expression:

$$T = 5.394 \sum_{i=1}^{17} q_i \, c_i \, n_i$$

where

T = total amount of nutrient (nitrogen or phosphorus) in pounds
q_i = average daily flow in cfs for the period represented by the ith sample
C_i = concentration of nutrient in mg/1
n_i = number of days in the period represented by the ith sample

Table 20. North Fork Salt Creek Water Quality Characteristics

Parameter	Upstream of lake Mean	Range	Downstream of lake Mean	Range
Turbidity, NTU	46.0	4.0-514.0	13.8	6.0-30.0
pH (dimensionless)		7.1-8.3		8.0-8.9
Alkalinity	210	82-274	134	108-160
Conductivity (umho/cm)	572	263-686	346	256-422
Total phosphate-P	0.11	0.01-0.97	0.06	0.01-0.12
Dissolved phosphate-P	0.05	0.00-0.38	0.01	0.00-0.02
Total ammonia-N	0.13	0.01-0.56	0.20	0.03-0.70
Nitrate-N	11.44	1.26-17.44	2.59	0.12-4.32
Kjeldahl-N	0.58	0.08-3.38	1.17	0.80-1.71
Dissolved solids	400	367-428	242	211-274
Total suspended solids	32	3-280	15	3-28
Volatile suspended solids	6	1-28	6	2-17

Note: Values in mg/L unless otherwise indicated

Because of the lack of reliable streamflow data, nutrient transport by the tributary could not be assessed for the whole year. Nutrient transport was assessed only for the months of May to July 1985 (table 21). Through extrapolation of the data in proportion to the rainfall amounts during the months of May to July 1985 and the period May 1985 to April 1986, this information was used to estimate the total nutrient transport for a 1-year period in developing a nutrient budget for the lake

Samples were collected from the tributary soon after significant rainstorms during the project period. The results of the analyses are shown in table 22. The values observed for various parameters with the exception of suspended solids were within the range of values observed for routine samples. The mean total and volatile suspended solids were three to six times higher during storm events than during baseflow periods.

The nitrogen and phosphorus concentrations measured in rainwater samples collected within the state park are shown in appendix 9. The means of measured total and dissolved phosphate-P were 0.29 and 0.24 mg/L, respectively. The ammonia-N and nitrate-N values were 0.98 and 0.89 mg/L. Nutrient input from a total of 39.94 inches of rainfall on the lake surface was computed from the averages of the observed values.

The phosphorus and nitrogen loads emanating from the state park's water treatment plant backwash water were assessed by monitoring the backwash water quality characteristics. The results for 39 discrete samples are given in appendix 10. The average total and dissolved phosphate-P for the backwash water samples were 0.13 and 0.09 mg/L respectively, and the ammonia and nitrate values were 1.02 and 8.37 mg/L. There were 39 backwashes in the one-year study period, and the volume of water for each backwash was taken as 4000 gallons (535 cu ft) as suggested in the operation and maintenance manual. These data were used in estimating the point source nutrient contribution to the lake.

Table 21. Nutrient Transports of North Fork Salt Creek
(Pounds)

Months, 1985	Upstream of lake: Inorganic nitrogen	Dissolved phosphorus	Total phosphorus	Downstream of lake: Inorganic nitrogen	Dissolved phosphorus	Total phosphorus
May	1394.87	0.69	2.29	942.85	6.03	13.77
June	3467.97	3.72	4.23	311.73	1.74	13.67
July	3044.52	14.83	29.06	291.49	4.51	20.90

Table 22. Water Quality Characteristics of North Fork
Salt Creek after Significant Rainfalls

Parameter	Upstream of lake: Mean	Range	Downstream of lake: Mean	Range
Turbidity	73	12-224	14	10-25
Total phosphate-P	0.20	0.02-0.54	0.10	0.07-0.22
Dissolved phosphate-P	0.06	0.00-0.20	0.03	0.01-0.07
Total ammonia-N	0.13	0.04-0.31	0.26	0.11-6.69
Nitrate-N	8.66	0.40-16.19	0.78	0.06-3.40
Total suspended solids	201	10-562	38	9-105
Volatile suspended solids	20	1-48	7	3-20

Note: Values in mg/L except for turbidity (NTU)

For assessing the internal regeneration of nutrients from lake bottom sediments, reliance was placed on values reported in the literature. Vollenweider (1968) estimated sediment nutrient release rates of 1.2 and 0.01 g/m^2/day for ammonia and phosphorus, respectively, under anaerobic conditions. Fillos and Swanson (1975) reported phosphorus release rates of 1.2 and 26.0 mg/m^2/day under aerobic and anaerobic conditions, respectively, for the Lake Warner, Massachusetts, sediment samples. USEPA's Clean Lakes Program Guidance Manual (1980) suggests values of 0.5 to 5 g/m^2/year under aerobic conditions and 10 to 20 g/m^2/yr under anaerobic conditions.

During the summer stratification period, June through September, approximately 48 acres of lake bottom remain anoxic. On the basis of the release rates suggested by Vollenweider, amounts of inorganic nitrogen and phosphorus released from the lake bottom sediments during this period were calculated. Phosphorus released from bottom sediments under anaerobic conditions was taken to be in soluble form.

The nutrient budget for Dawson Lake is shown in table 23. The impact of septic tank tile fields near the concession stand and the Gander Bay camping area is considered negligible. Several field inspections indicated that the tile drain was dry or that the ground over and around the field tiles was not water-logged, indicating that the hydraulic loading to the septic tank systems is less than the capacities of these systems.

Table 23. Nutrient Budget for Dawson Lake

Source	Inorganic nitrogen	Dissolved phosphorus	Total phosphorus
Tributary	23,308	57	105
Water treatment plant discharge	12	«1	«1
Precipitation	2,537	326	393
Internal regeneration	61,660	514	514
Gross loading	87,517	897	1,012
Outflow	4,557	36	142
Net loading	82,960	861	870
Percent retained	94.8	96.0	86.0

Note: Values are expressed as pounds per year except for percent retained

Gross nutrient loading, which is the sum total of nutrient inputs from all the sources considered, is also given in table 23. Allowing for nutrient outflow from the impoundment, the net nutrient loadings for Dawson Lake were found to be 62.0 $g/m^2/yr$ for inorganic nitrogen, 0.64 $g/m^2/yr$ for dissolved phosphorus, and 0.65 $g/m^2/yr$ for total phosphorus, all based on the total surface area of the lake. The corresponding data for Johnson Sauk Trail Lake were reported as 60.8 $g/m^2/yr$, 0.58 $g/m^2/yr$, and 0.44 $g/m^2/yr$.

The relative importance of various sources of nutrients is tabulated in table 24.

As in the case of Johnson Sauk Trail Lake, internal regeneration of nutrients under anoxic conditions is the major nutrient source. The tributary is the second major source of inorganic nitrogen, and precipitation is a more significant source of phosphorus to the lake than the tributary. Water treatment plant process waste discharge has no significant impact on the lake.

Trophic State

Eutrophication is a natural aging process that affects every body of water from the time of its formation. Many interacting factors contribute to the overall process of eutrophication, a term more widely known to mean the nutrient enrichment of waters. The eutrophication of a lake system consists of a gradual progression from one life stage to another based upon changes in the degree of nutrient input or productivity. The earliest stage of the life cycle is characterized by low concentrations of plant nutrients and little biological productivity. Lakes in this stage are called oligotrophic lakes. At a later stage in the succession, the lake becomes mesotrophic, and as the life cycle continues the lake becomes eutrophic or highly productive. The final life stage before extinction is a pond, marsh, or swamp.

Table 24. Relative Importance of Nutrient Sources
(Percent of total)

Source	Inorganic nitrogen	Dissolved phosphorus	Total phosphorus
Tributary	26.6	6.4	10.4
Water treatment plant discharge	0.0	0.0	0.0
Precipitation	2.9	36.3	38.8
Internal regeneration	70.5	57.3	50.8

As a lake ages, the degree of enrichment by nutrient materials increases. In general, the lake traps a portion of the nutrients originating in the surrounding drainage basin. In addition, precipitation, dry fallout, and in certain cases ground-water inflow are contributing sources. The shore vegetation and higher aquatic plants utilize part of the inflowing nutrients, grow abundantly, and in turn trap the sediments. The lake gradually fills in, becoming shallower by the accumulation of plants and sediments on the bottom and smaller by the invasion of shore vegetation, and eventually becomes dry land. The extinction of a lake is the result of enrichment, productivity, decay, and sedimentation.

Human activities, such as the alteration of lake drainage basins, agricultural practices, deforestation, and urban development, have hastened the nutrient addition to natural waters. When the pollutants are of a nutritional type, the enrichment of the recipient water is greatly accelerated and the rate of aging is consequently greatly increased. In this way, eutrophication resulting from human activities can significantly alter the rate of the natural process and shorten the life expectancy of the affected body of water.

Because eutrophic lakes contain an abundance of available nutrients, biological production is high and results in nuisance growths, which adversely affect human use of the water body. Plants, particularly algae, are of primary concern because they utilize dissolved inorganic nutrients from the water and thus become primary producers of new organic matter on which aquatic animal life depends. In eutrophic lakes the phytoplankton are represented by large numbers of a few species. An overabundance of algae is generally called an algal bloom. Lackey (1949) and later Fruh (1967) arbitrarily defined an algal bloom as 500 cts/ml of raw water sample.

With the increased productivity associated with accelerated rates of eutrophication comes the filling of lake basins with organic materials, which subsequently exert an increased oxygen demand on the overlying waters. The increased oxygen demand may result in total depletion of oxygen in the cooler bottom waters during the summer, accompanied by an increase in the products of decomposition, e.g., carbon dioxide, ammonia, hydrogen sulfide, and methane. These developing anaerobic conditions result in the replacement of desirable benthic organisms with less desirable types.

In addition to restricting fish populations, highly eutrophic lakes are undesirable aesthetically and with respect to water use. Algal blooms produce taste and odor problems and create unsightly surface scums which discourage water contact recreational activities. Accumulation of algal mats and dense weed growths is most pronounced near shore. The accumulated algal masses decay, resulting in extremely foul-smelling conditions.

A wide variety of indices of trophic conditions has been suggested in the literature. Indices have been based on secchi disc transparency, hypolimnetic oxygen depletion, nutrient concentrations, and biological parameters including species abundance and diversity. USEPA (1980) suggests in its Clean Lakes Program Guidance Manual (table 10-4) the use of four parameters as trophic indicators: secchi disc transparency, carbon, phosphorus concentrations, and concentrations of chlorophyll-a. The criteria suggested therein are reproduced here as table 25.

The mean surface phosphorus concentration observed at the deep station in Dawson Lake for the months of November to March was 87 ug/1, which is three times the upper limit value for eutrophic lakes shown in table 25. The mean summer secchi disc transparency in the lake was 2.50 feet or 0.7 meter. This is less than the lower limit suggested in the table. It must be pointed out that in the case of Dawson Lake, turbidity is caused not only by phytoplankton but also by inorganic particulate matter of both autochthonous and allochthonous origins. The average summer chlorophyll-a concentration in the lake was found to be 43 ug/1, which again was higher than the value indicated for eutrophic lakes.

Algal counts in the lake during summer months were generally not of bloom proportions. Nitrogen-phosphorus ratio values shown for the lake surface water samples in table 26 indicate that these ratios were generally much higher than 15, denoting a phosphorus limiting condition. The mean and range of values for the deep station were 58 and 14 - 206. For the shallow station, these values were 46 and 10 - 118. The comparable values for Johnson Sauk Trail Lake were 23 and 5 - 37 (Kothandaraman and Evans, 1983a). The nitrogen concentrations in Dawson Lake were much higher.

Vollenweider (1968) suggested that for lakes with a mean depth of 5 meters (16.4 feet) or less, permissible loading levels of biochemically active nitrogen and phosphorus are, respectively, 1.0 and 0.07 $g/m^2/yr$. For

Table 25. Quantitative Definitions of Lake Trophic State (USEPA, 1980)

Characteristics	Oligotrophy	Eutrophy
Total phosphorus (winter), ug/1	<10-15	>20-30
Chlorophyll-a (summer), ug/1	≤2-4	≥6-10
Secchi disc depth (summer), meters	>3-5	<1.5-2
Primary productivity		
Carbon ($mg/m^2/yr$)	30-100	300-3000
Carbon ($ug/m^2/day$)	7-25	75-700

Note: Mesotrophy exists between the limits for oligotrophy and eutrophy

Table 26. Nitrogen-Phosphorus Ratios for the Near-Surface Water Samples in Dawson Lake

Date of sample collection	Deep Station Total nitrogen (mp/1)	Deep Station Total phosphorus (mg/1)	Deep Station N/P ratio	Shallow Station Total nitrogen (mg/1)	Shallow Station Total phosphorus (mg/1)	Shallow Station N/P ratio
5/6/85	4.26	.0.09	47	6.27	0.13	48
5/20	4.11	0.02	206	4.72	0.04	118
6/13	3.79	0.05	76	3.90	0.09	43
6/17	2.96	0.06	49	3.42	0.06	57
7/1	2.44	0.05	49	2.50	0.06	42
7/15	2.04	0.07	29	2.33	0.11	21
7/29	0.99	0.07	14	1.55	0.08	19
8/12	1.18	0.08	15	1.37	0.07	20
8/26	1.39	0.07	20	1.43	0.10	14
9/9	1.21	0.06	20	1.55	0.15	10
9/20	1.73	0.06	29-	1.65	0.11	15
10/7	0.97	0.06	16	1.19	0.12	10
11/14	3.25	0.12	27	7.59	0.24	32
2/1/86	4.52	0.06	75	6.85	0.10	69
3/31	7.38	0.08	92	6.21	0.07	89
4/14	5.12	0.06	85	5.17	0.09	57
5/12	3.91	0.03	130	4.72	0.04	118

the same average depth, loading rates greater than 2.0 $g/m^2/yr$ for nitrogen and 0.13 $g/m^2/yr$ for phosphorus are considered excessive from the point of view of eutrophication. The mean depth of Dawson Lake is 9.3 feet. The loading rates of total inorganic nitrogen and dissolved phosphorus for the lake were estimated as 62.0 and 0.64 $g/m^2/yr$. Excluding the nutrient contribution from internal regeneration from lake bottom sediments under anaerobic conditions during summer months, these loading rates would be 18.3 and 0.27 $g/m^2/yr$.

In addition, the lake trophic index system developed by Carlson (1977) on the basis of secchi disc transparencies, chlorophyll-a, and total phosphorus values was used to evaluate the trophic status of the lake. This numerical index ranges from 0 to 100. Lakes with trophic state index (TSI) values less than 40 are classified as oligotrophic (nutrient-poor, or relatively unproductive, biologically speaking), and those with TSI values greater than 50 are classified as eutrophic (highly productive). Each major division (10, 20, 30, etc.) represents a doubling of biomass.

The TSI values not only assist in evaluating the trophic condition of a lake but also permit an assessment of the changes in a lake after implementation of a management scheme to improve its overall quality. They also permit comparison among lakes.

The TSI values for Dawson Lake based on secchi disc observations ranged from 53 to 75 with a mean value of 66. The values for Johnson Sauk Trail Lake were reported as 46 to 87 with a mean of 60. Even though Johnson Sauk

Trail Lake exhibited much more severe water quality problems than Dawson Lake as measured by such factors as dissolved oxygen depletion, algal blooms, and macrophyte growths, Dawson Lake has poorer TSI values on the basis of secchi disc readings. Lack of water clarity in Dawson Lake is caused by inorganic particulate matter more than is the case in Johnson Sauk Trail Lake. The predominant land use in the Dawson Lake watershed is agriculture, whereas there is practically no land disturbance in the Johnson Sauk Trail Lake watershed. Hawes et al. (1986) reported that in 1985 the secchi disc values for Dawson Lake varied from 8 to 39 inches with a mean of 8 inches. They noted that suspended sediments were substantial in the lake.

The TSI values based on total phosphate for Dawson Lake varied from 47 to 73 with a mean of 63. The TSI values based on chlorophyll-a varied from 60 to 73 with a mean of 67. The mean TSI values based on the water quality parameters secchi disc transparency, total phosphorus, and chlorophyll-a were respectively 60, 63, and 67. The overall mean of the TSI values was 63.

By all measures of trophic state indexes, Dawson Lake has to be reckoned as a eutrophic lake. However, the water quality problems in the lake do not warrant the institution of additional in-lake water quality management schemes other than the periodic lake drawdown already being practiced. There is only minimal stratification in the lake during summer months. During the period of peak stratification, the lake is devoid of oxygen only at depths below 14 feet from the surface, and only 16.2 percent of the lake volume is anoxic. Phytoplankton growths are not of bloom proportion and blue-green algae are not dominant. Rooted vegetation is sparse and does not appear to interfere with recreational activities.

SUMMARY

Dawson Lake, formed in 1963 by the damming of North Fork Salt Creek, is a 150-acre lake with a total watershed area of 2828 acres. The lake and the surrounding park, which are publicly owned, are managed by the Illinois Department of Conservation for recreational purposes such as fishing, boating, picnicking, camping, horseback riding, hiking, hunting, and other outdoor activities. The park system is open to the public throughout the year.

Twenty-nine percent of the lake's watershed is in state ownership, and the rest is in small private holdings. Agriculture is the predominant land use in the watershed, constituting 65.5 percent of the total. There is no land use activity within the state-owned lands which involves land disturbance. The only point source waste discharge within the watershed, the state park water treatment plant backwash discharge, has practically no impact on the lake.

The lake experiences summer stratification. During the peak stratification period, the lake was anoxic at depths below 14 feet from the surface, and about 16.2 percent of the lake volume was anoxic. Average secchi disc transparency during the summer was found to be about 2.75 feet.

The lake water quality characteristics were found to be typical of midwestern lakes with high alkalinity, conductivity, and dissolved solids values. The total and dissolved phosphorus levels in the lake after spring turnover were 0.08 and 0.01 mg/1, respectively. Inorganic nitrogen and total phosphorus loadings to the lake were estimated respectively as 62.0 and 0.65 $g/m^2/yr$.

The lake experiences moderate biological productivity. Except for two observations, the total algal counts at the deep station of the lake were found to be well below densities considered to be of bloom proportion. Scum-forming blue-green algae were not dominant. Chlorophyll-a levels ranged from 22.2 to 62.0 ug/1 with an average value of 40.3 ug/1. The ratios of total nitrogen to total phosphorus in the lake waters indicate that phosphorus could be a limiting nutrient. About 10.1 acres of the lake, 6.7 percent of the total lake surface, had moderate growths of macrophytes. Horned pondweed was the dominant species observed in the lake.

On the basis of a sediment survey of the lake, it was estimated that the volume of water storage has decreased 8.8 percent in 22.5 years, a rate of 0.40 percent per year. The lake received sediments from its watershed at the annual rate of 2.7 tons/acre. The McLean County Soil and Water Conservation District reports that about 878 acres of farmland have sufficient soil erosion protection, with another 637 acres in conservation tillage. The District estimates that the soil loss from the farmland has been reduced from 6554 tons/year to 2622 tons/year with all the conservation practices in place. The soil loss from the watershed is estimated to be at or below tolerable limits.

On the basis of conditions which prevail in the lake and the excellent soil erosion control management practices adopted in the watershed, there appears to be no need for water quality improvement measures at the present time.

REFERENCES

American Public Health Association, American Water Works Association, and Water Pollution Control Federation. 1985. Standard methods for the examination of water and wastewater. American Public Health Association, Washington, DC, 1268 p., 15th edition.

Butts, T.A., and R.L. Evans. 1979. Sediment oxygen demand in a shallow oxbow lake. Illinois State Water Survey Circular 136, 38 p.

Carlson, R.E. 1977. A trophic state index for lakes. Limnology and Oceanography, v. 22(2): 361-369.

Fillos, J., and W.R. Swanson. 1975. The release rate of nutrients from river and lake sediments. Journal Water Pollution Control Federation. v. 47(5):1032-1042.

Fitzpatrick, W.P. 1987. Sedimentation survey of Dawson Lake. Moraine View State Park. McLean County. Illinois. Illinois State Water Survey Contract Report 413, 26 p.

Fruh, E.G. 1967. The overall picture of eutrophication. Journal Water Pollution Control Federation v. 39(9):1449-1463.

Greeson, P.E. 1971. Limnology of Lake Oneida with emphasis on factors con-

185 p.

Hawes, J., K. Luly, and W. Hammel. 1986. Volunteer lake monitoring program. 1985. Volume v. east central Illinois region. Division of Water Pollution Control and Office of Community Relations, Illinois Environmental Protection Agency, pp. 56-69.

Hutchinson, G. Evelyn. 1957. A treatise on limnology. Volume I: geography. physics, and chemistry. John Wiley and Sons, Inc., New York, 1015 p.

Illinois Pollution Control Board. 1986. State of Illinois. rules and regulations, title 35: environmental protection. subtitle C: water pollution, chapter I. 44 p.

Kothandaraman, V., and R.L. Evans. 1975. Some water quality aspects in a nascent impoundment in central Illinois. Transactions Illinois State Academy of Science v. 68(3): 292-303.

Kothandaraman, V., and R.L. Evans. 1983a. Diagnostic-feasibility study of Johnson Sauk Trail Lake. Illinois State Water Survey Contract Report 312, 126 p.

Kothandaraman, V., and R.L. Evans. 1983b. Diagnostic-feasibility study of Lake Le-Aqua-Na. Illinois State Water Survey Contract Report 313, 113 P.

Lackey, J.B. 1949. Plankton as related to nuisance conditions in surface water, limnological aspects of water supply and waste disposal. American Association for the Advancement of Science, v. 109 (2821): 56-63.

Mackenthun, K.M. 1969. The practice of water pollution biology. United State Department of the Interior, Federal Water Pollution Control Administration, 281 p.

Roberts, W.J., and J.B. Stall. 1967. Lake evaporation in Illinois. Illinois State Water Survey Report of Investigation 57, 44 p.

Roseboom, D.P., R.L. Evans, and T.E. Hill. 1978. Water quality in Cedar lake and the relevance of its watershed. Illinois State Water Survey Contract Report 192, 93 p.

Roseboom, D.P., R.L. Evans, W. Wang, T.A. Butts, and R.M. Twait. 1979. Classifying Illinois impoundments: an examination of techniques for assessing lake bottom conditions. Illinois State Water Survey Contract Report 215, 155 p.

Sawyer, C.N. 1952. Some new aspects of phosphate in relation to fertilization. Sewage and Industrial Wastes v. 24(6): 768-776.

Symons, J.C . 1969. Water quality behavior in reservoirs. U.S. Department of Health, Education, and Welfare, Public Health Service, Bureau of Water Hygiene, Cincinnati, OH, 616 p.

U.S. Environmental Protection Agency. 1980. Clean lakes program guidance manual. EPA-440/5-81-003, Office of Water Regulations and Standards, Washington, DC, 103 p. plus appendices.

Vollenweider, R.A. 1968. Scientific fundamentals of lakes and flowing waters, with particular reference to nitrogen and phosphorus as factors in eutrophication. Organization for Economic Cooperation and Development, Paris DAS/CSI/68.27, 159 p.

Wang, W.C., W.T. Sullivan, and R.L. Evans. 1973. A technique for evaluating algal growth potential in Illinois surface waters. Illinois State Water Survey Report of Investigation 72, 16 p.

Appendix 1. Dissolved Oxygen, Temperature Observations in Dfluann Lake, Deep Station

Depth	5/06/85		5/20/85		6/03/85		6/17/85		7/01/85		7/15/85	
(feet)	D.O.	Temp.	D.O.	Temp.	D.O.	Temp.	D.O.	Temp.	D.O.	Temp.	D.O.	Temp.
0	11.8	19.0	10.2	20.5	9.1	23.1	10.2	22.2	9.5	25.5	8.8	26.0
2	11.2	18.5	10.2	20.5	9.0	23.1	10.1	22.2	9.5	25.0	8.8	26.0
4	11.0	18.5	9.9	20.5	8.5	22.5	8.6	21.5	9.5	24.5	8.7	26.0
6	10.2	18.5	8.6	19.5	8.4	22.5	7.0	20.1	8.7	24.0	8.5	26.0
8	9.9	18.0	8.2	19.5	8.4	22.5	6.4	19.9	6.9	24.0	7.4	25.5
10	9.4	18.0	8.0	19.0	8.3	22.3	5.3	19.4	6.5	24.0	7.4	25.5
12	8.3	18.0	5.9	18.3	6.9	21.9	5.0	19.3	1.8	22.5	6.5	25.5
14	8.3	17.0	5.4	18.0	3.8	21.3	4.1	19.1	0.5	22.0	1.9	24.5
16	----	----	4.8	18.0	1.0	20.3	3.3	19.0	0.4	20.5	0.8	22.5
18	----	----	4.4	17.8	0.1	19.2	1.3	18.7	0.4	19.5	0.7	21.0
20	----	----	4.2	17.5	0.1	18.1	0.1	18.5	0.4	19.0	0.6	20.0
21	----	----	----	----	0.1	17.8	----	----	0.4	19.0	----	----
22	----	----	3.4	17.5	----	----	----	----	----	----	0.6	19.0

Depth	7/29/85		8/12/85		8/26/85		9/09/85		9/20/85		10/07/85	
(feet)	D.O.	Temp.	D.O.	Temp.	D.O.	Temp.	D.O.	Temp.	D.O.	Temp.	D.O.	Temp.
0	11.8	29.0	9.1	26.0	6.9	23.1	8.5	27.0	8.5	21.0	9.9	14.1
2	13.4	28.0	9.1	26.0	6.7	23.1	8.5	26.9	8.5	21.0	10.0	14.0
4	13.1	27.5	9.0	26.0	6.1	23.0	8.5	26.6	8.5	21.0	9.9	13.9
6	8.8	26.5	8.8	26.0	5.4	22.8	8.2	26.5	8.5	21.0	9.9	13.8
8	3.5	26.0	4.7	25.0	5.3	22.8	4.0	25.7	8.3	21.0	9.9	13.7
10	2.5	25.0	1.6	24.5	5.3	22.8	0.4	24.5	5.9	20.5	9.9	13.7
12	1.0	25.0	1.1	24.5	5.3	22.8	0.1	23.8	3.9	20.0	9.9	13.7
14	0.2	24.9	0.7	24.5	5.7	22.8	0.1	22.8	3.4	20.0	9.9	13.7
16	0.2	24.0	0.6	24.0	5.9	22.8	0.1	22.2	2.9	20.0	9.8	13.7
18	0.2	22.5	----	----	5.8	22.8	0.0	21.3	2.5	20.0	9.8	13.7
19	----	----	----	----	5.2	22.6	----	----	----	----	----	----
20	----	----	----	----	3.0	22.5	0.0	20.6	2.0	20.0	9.7	13.6
21	----	----	----	----	----	----	0.0	20.0	----	----	----	----
22	----	----	----	----	0.3	21.5	----	----	1.8	20.0	9.6	13.5
23	----	----	----	----	0.0	20.0	----	----	----	----	----	----

Note: D.O.—mg/L; Temperature—degrees Celsius

Appendix 1. Dissolved Oxygen, Temperature Observations in Dawson Lake, Deep Station, concluded

Depth (feet)	11/14/85 D.O.	11/14/85 Temp.	3/18/86 D.O.	3/18/86 Temp.	3/31/86 D.O.	3/31/86 Temp.	4/14/86 D.O.	4/14/86 Temp.	4/28/86 D.O.	4/28/86 Temp.	5/12/86 D.O.	5/12/86 Temp.
0	12.6	9.2	13.0	6.2	14.6	13.3	12.4	13.5	8.9	16.2	13.8	23.6
2	12.6	9.1	13.0	6.0	14.7	13.2	12.5	13.4	8.9	16.3	14.0	21.3
4	12.6	9.1	13.0	6.0	14.6	13.1	12.5	13.4	8.8	16.3	13.4	20.7
6	12.4	8.8	13.0	6.0	14.4	12.6	12.4	13.5	8.8	16.2	14.0	20.4
8	11.4	8.8	12.9	6.0	12.8	11.1	12.4	13.4	8.8	15.9	11.8	19.9
10	11.3	8.8	13.0	6.0	12.4	10.2	12.4	13.5	8.8	15.7	9.3	19.0
12	11.4	8.8	13.0	6.0	12.4	9.9	12.4	13.4	7.5	14.4	5.2	17.1
14	11.4	8.8	12.9	5.9	12.4	9.8	12.4	13.4	6.9	12.8	4.6	16.3
16	11.2	8.8	12.9	5.9	12.4	9.0	12.4	13.4	5.8	12.3	2.7	15.4
18	11.1	8.8	12.9	5.9	11.6	8.8	12.0	13.3	5.6	12.8	0.7	14.9
19	----	----	----	----	----	----	----	----	----	----	0.5	14.8
20	----	----	12.9	5.9	11.6	8.7	11.5	13.2	5.3	12.1	----	----
22	----	----	12.9	5.9	10.0	8.3	11.0	13.2	4.9	12.1	----	----
24	----	----	12.9	5.9	----	----	9.0	13.2	4.6	12.1	----	----
25	----	----	12.9	5.9	----	----	----	----	----	----	----	----

Depth (feet)	5/27/86 D.O.	5/27/86 Temp.
0	12.1	20.3
2	12.2	20.2
4	12.2	20.1
6	12.3	19.8
8	11.6	19.0
10	8.0	17.5
12	7.2	17.2
14	4.6	16.8
16	2.9	16.7
18	0.4	16.3
20	0.1	15.7
22	0.1	14.8

Note: D.O.—mg/L; Temperature—degrees Celsius

Appendix 2. Dissolved Oxygen, Temperature Observations in Dawson Lake, Shallow Station

Depth	5/06/85		5/20/85		6/03/85		6/17/85		7/01/85		7/15/85	
(feet)	D.O.	Temp.	D.O.	Temp.	D.O.	Temp.	D.O.	Temp.	D.O.	Temp.	D.O.	Temp.
0	12.3	22.0	10.2	20.8	7.4	23.2	9.0	23.3	9.5	24.5	9.2	27.0
1	12.3	22.0	10.2	20.8	7.4	22.4	9.0	23.3	9.5	24.0	9.2	27.0
2	12.3	22.0	10.2	20.8	7.3	22.3	9.0	23.3	9.5	24.0	8.7	26.5
3	12.2	22.0	10.2	20.8	7.1	22.2	9.0	23.3	9.5	24.0	7.9	26.0
4	10.9	21.0	10.2	20.8	6.9	22.1	8.9	23.2	9.2	23.5	7.6	26.0
5	9.2	19.5	10.0	20.8	6.3	22.0	7.2	22.2	9.0	23.5	6.0	25.5
6	----	----	7.4	19.5	4.9	21.8	5.9	21.0	8.9	23.0	5.8	24.5
7	----	----	----	----	2.7	21.0	----	----	3.1	23.0	5.4	23.0

Depth	7/29/85		8/12/85		8/26/85		9/09/85		9/20/85		10/07/85	
(feet)	D.O.	Temp.	D.O.	Temp.	D.O.	Temp.	D.O.	Temp.	D.O.	Temp.	D.O.	Temp.
0	11.1	29.0	8.4	25.5	8.4	22.8	7.5	27.8	9.3	22.5	11.6	14.3
1	10.8	28.0	8.4	25.5	8.0	22.8	7.5	27.6	9.3	22.5	11.8	14.2
2	10.5	27.0	8.4	25.5	7.3	22.4	7.3	27.6	8.9	22.5	11.8	14.0
3	9.6	27.0	8.4	25.5	7.1	22.1	7.4	27.5	8.8	22.0	11.7	13.9
4	8.1	27.0	7.8	25.0	6.7	22.1	6.7	27.3	8.3	22.0	11.6	13.3
5	6.8	26.5	6.8	24.5	6.7	22.1	6.7	27.3	8.1	22.0	11.4	13.0
6	4.6	26.0	5.9	24.5	6.7	22.0	6.7	27.2	7.9	22.0	11.0	12.8

Depth	11/14/85		3/18/86		3/31/86		4/14/86		4/28/86		5/12/86	
(feet)	D.O.	Temp.	D.O.	Temp.	D.O.	Temp.	D.O.	Temp.	D.O.	Temp.	D.O.	Temp.
0	9.4	10.7	13.0	7.0	12.8	15.0	13.2	13.2	7.9	17.9	11.9	23.9
1	9.3	10.8	13.1	7.0	12.8	15.0	13.2	13.9	7.9	18.1	12.7	23.1
2	9.3	10.8	13.1	6.9	12.9	15.0	13.1	13.9	7.9	18.1	12.2	22.0
3	9.2	10.8	13.1	6.9	12.8	14.9	13.2	13.9	7.9	18.1	12.1	21.3
4	9.2	10.8	13.1	6.9	12.8	14.9	13.2	13.9	7.9	18.1	11.5	20.9
5	9.1	10.8	13.1	6.9	12.7	14.9	13.2	13.9	7.9	18.1	9.7	20.3
5.5	----	----	13.1	6.9	----	----	----	----	----	----	----	----
6	----	----	----	----	----	----	13.2	13.9	7.8	18.1	8.9	20.2
6.5	----	----	----	----	----	----	----	----	----	----	7.9	19.9

Depth	5/27/86	
(feet)	D.O.	Temp.
0	11.3	20.7
1	11.1	20.8
2	11.0	20.7
3	11.0	20.2
4	10.4	19.2
5	9.6	19.2
6	8.6	18.2
7	7.3	16.3

Note: D.O.—mg/L; Temperature—degrees Celsius

Appendix 3. Percent Dissolved Oxygen Saturation in Dawson Lake, Deep Station

Depth (feet)	5/06/85	5/20/85	6/03/85	6/17/85	7/01/85	7/15/85
0	128.1	114.2	107.3	118.2	117.3	109.7
2	120.4	114.2	106.1	117.0	116.2	109.7
4	118.2	110.9	99.0	98.3	115.1	108.5
6	109.6	94.4	97.9	77.7	104.4	106.0
8	105.3	90.0	97.9	70.8	82.8	91.4
10	100.0	86.9	96.3	58.0	78.0	91.4
12	88.3	63.1	79.5	54.6	21.0	80.3
14	86.4	57.4	43.2	44.6	5.8	23.0
16	----	51.0	11.2	35.8	4.5	9.3
18	----	46.6	1.1	14.0	4.4	7.9
20	----	44.2	1.1	1.1	4.3	6.7
21	----	----	1.1	----	4.3	----
22	----	35.8	----	----	----	6.5

Depth (feet)	7/29/85	8/12/85	8/26/85	9/09/85	9/20/85	10/07/85
0	155.7	113.4	81.4	108.0	96.1	96.7
2	173.5	113.4	79.0	107.8	96.1	97.4
4	168.0	112.2	71.8	107.2	96.1	96.3
6	110.8	109.7	63.3	103.2	96.1	96.0
8	43.6	57.5	62.1	49.6	93.9	95.8
10	30.6	19.4	62.1	4.8	66.1	95.8
12	12.2	13.3	62.1	1.2	43.2	95.8
14	2.4	8.5	66.8	1.2	37.7	95.8
16	2.4	7.2	69.2	1.2	32.1	94.9
18	2.3	----	68.0	0.0	27.7	94.9
19	----	----	60.7	----	----	----
20	----	----	35.0	0.0	22.2	93.7
21	----	----	----	0.0	----	----
22	----	----	3.4	----	20.0	92.5
23	----	----	0.0	----	----	----

Appendix 3. Percent Dissolved Oxygen Saturation in Dawson Lake, Deep Station, concluded

Depth (feet)	11/14/85	3/18/86	3/31/86	4/14/86	4/28/86	5/12/86
0	109.6	104.9	140.0	119.5	91.1	164.3
2	109.4	104.3	140.7	120.2	91.3	159.3
4	109.4	104.3	139.4	120.2	90.2	150.7
6	106.8	104.3	135.9	119.5	90.0	156.4
8	98.2	103.5	116.6	119.2	89.5	130.5
10	97.3	104.3	110.6	119.5	89.1	101.0
12	98.2	104.3	109.7	119.2	73.7	54.3
14	98.2	103.3	109.5	119.2	65.4	47.2
16	96.5	103.3	107.4	119.2	54.4	27.1
18	95.6	103.3	99.9	115.1	53.1	7.0
19	----	----	----	----	----	5.0
20	----	103.3	99.7	110.0	49.4	----
22	----	103.3	85.1	105.3	45.7	----
24	----	103.3	----	86.1	42.9	----
25	----	103.3	----	----	----	----

Depth (feet)	5/27/86
0	134.9
2	135.8
4	135.5
6	135.8
8	126.0
10	84.2
12	75.3
14	47.7
16	30.0
18	4.1
20	1.0
22	1.0

Appendix 4. Percent Dissolved Oxygen Saturation in Dawson Lake, Shallow Station

Depth (feet)	5/06/85	5/20/85	6/03/85	6/17/85	7/01/85	7/15/85
0	141.9	114.9	87.4	106.5	115.1	116.9
1	141.9	114.9	86.1	106.5	114.0	116.9
2	141.9	114.9	84.7	106.5	114.0	109.5
3	140.8	114.9	82.2	106.5	114.0	98.5
4	123.3	114.9	79.8	105.1	109.3	94.7
5	100.9	112.7	72.7	83.4	106.9	74.1
6	----	81.2	56.3	66.7	104.7	70.3
7	----	----	30.5	----	36.5	63.5

Depth (feet)	7/29/85	8/12/85	8/26/85	9/09/85	9/20/85	10/07/85
0	146.5	103.7	98.5	96.7	108.4	113.8
1	139.8	103.7	93.8	96.4	108.4	115.5
2	133.4	103.7	84.9	93.8	103.7	115.0
3	122.0	103.7	82.1	94.9	101.5	113.8
4	102.9	95.4	77.5	85.6	95.8	111.3
5	85.6	82.4	77.5	85.6	93.5	108.6
6	57.3	71.5	77.3	85.4	91.2	104.3

Depth (feet)	11/14/85	3/18/86	3/31/86	4/14/86	4/28/86	5/12/86
0	84.8	107.0	127.6	126.3	83.8	142.5
1	84.1	107.9	127.6	128.3	84.2	149.7
2	84.1	107.6	128.6	127.4	84.2	140.8
3	83.2	107.6	127.3	128.3	84.2	137.7
4	83.2	107.6	127.3	128.3	84.2	129.8
5	82.3	107.6	126.3	128.3	84.2	108.2
5.5	----	107.6	----	----	----	----
6	----	----	----	128.3	83.1	99.1
6.5	----	----	----	----	----	87.4

Depth (feet)	5/27/86
0	127.0
1	125.0
2	123.7
3	122.4
4	113.4
5	104.7
6	91.8
7	74.9

Appendix 5A. Physical and Chemical Quality Characteristics of Surface Waters in Dawson Lake, Deep Station

Parameter	5/06/85	5/20/85	6/03/85	6/17/85	7/01/85	7/15/85
Secchi, inches	24.00	24.00	34.00	39.00	33.00	24.00
Turbidity, NIU	16.00	12.00	8.00	9.00	8.00	13.00
pH (dimensionless)	9.00	8.30	8.00	8.70	8.80	8.90
Alkalinity	89.00	115.00	109.00	125.00	110.00	117.00
Conductivity, umho/cm	264.00	270.00	272.00	27 8.00	251.00	315.00
Total phosphate-P	.09	.02	.05	.06	.05	.07
Dissolved phosphate-P	.02	.01	.01	.01	0.00	.02
Total ammonia-N	.04	.11	.06	.09	.17	.12
Nitrate-N	3.69	3.12	2.61	1.83	1.36	.88
Kjeldahl-N	.53	.88	1.12	1.04	.91	1.04
Dissolved solids	231.00	250.00	260.00	260.00	208.00	222.00
Total suspended solids	12.00	10.00	9.00	11.00	11.00	13.00
Volatile suspended solids	7.00	3.00	8.00	6.00	8.00	8.00

Parameter	7/29/85	8/12/85	8/26/85	9/09/85	9/20/85	10/07/85
Secchi, inches	26.00	30.00	24.00	42.00	29.00	22.00
Turbidity, NIU	10.00	13.00	17.00	16.00	17.00	16.00
pH (dimensionless)	9.10	8.80	8.50	8.60	8.30	8.30
Alkalinity	112.00	110.00	117.00	119.00	123.00	123.00
Conductivity, µmho/cm	310.00	318.00	315.00	327.00	327.00	325.00
Total phosphate-P	.07	.08	.07	.06	.06	.06
Dissolved phosphate-P	.01	.03	.01	.01	.01	.01
Total ammonia-N	.05	.03	.23	.04	.18	.12
Nitrate-N	.34	.24	.14	.13	.15	.11
Kjeldahl-N	.60	.91	1.02	1.04	1.40	.74
Dissolved solids	248.00	230.00	204.00	220.00	216.00	244.00
Total suspended solids	12.00	26.00	18.00	18.00	13.00	18.00
Volatile suspended solids	6.00	7.00	7.00	8.00	10.00	6.00

Parameter	11/14/85	3/18/86	3/31/86	4/14/86	4/28/86	5/12/86
Secchi, inches	15.00	14.00	14.00	19.00	35.00	62.00
Turbidity, NIU	15.00	29.00	25.00	19.00	10.00	8.00
pH (dimensionless)	8.70	8.28	8.80	8.30	8.30	8.60
Alkalinity	140.00	142.00	125.00	154.00	157.00	153.00
Conductivity, µmho/cm	380.00	3%.00	406.00	420.00	421.00	411.00
Total phosphate-P	.12	.10	.08	.06	.04	.03
Dissolved phosphate-P	.02	.01	.02	.01	.03	.01
Total ammonia-N	.09	.05	.04	.05	.14	.09
Nitrate-N	1.49	4.02	5.89	3.57	3.44	3.08
Kjeldahl-N	1.67	1.43	1.45	1.50	.90	.74
Dissolved solids	228.00	274.00	292.00	272.00	358.00	290.00
Total suspended solids	18.00	25.00	26.00	18.00	17.00	7.00
Volatile suspended solids	4.00	8.00	18.00	11.00	3.00	2.00

Note: Values in mg/L unless otherwise indicated

Appendix 5A. Physical and Chemical Quality Characteristics of Surface Waters in Dawson Lake, Deep Station, concluded

Parameter	5/27/86
Secchi, inches	54.00
Turbidity, NTU	6.00
pH (dimensionless)	8.55
Alkalinity	149.00
Conductivity, µmho/cm	399.00
Total phosphate-P	.03
Dissolved phosphate-P	.01
Total ammonia-N	.17
Nitrate-N	2.43
Kjeldahl-N	.78
Dissolved solids	304.00
Total suspended solids	9.00
Volatile suspended solids	2.00

Note: Values in mg/L unless otherwise indicated

Appendix 5B. Physical and Chemical Quality Characteristics of Mid-Depth Waters in Dawson Lake, Deep Station

Parameter	5/06/85	5/20/85	6/03/85	6/17/85	7/01/85	7/15/85
Turbidity, NTU	16.00	14.00	11.00	9.00	11.00	12.00
pH (dimensionless)	8.85	8.20	8.80	8.10	8.60	8.75
Alkalinity	100.00	115.00	120.00	123.00	112.00	112.00
Conductivity, umho/cm	271.00	277.00	266.00	27 9.00	253.00	319.00
Total phosphate-P	.09	.06	.05	.05	.06	.07
Dissolved phosphate-P	.02	.01	.01	.01	.01	.01
Total ammonia-N	.19	.11	.02	.34	.14	.10
Nitrate-N	3.80	3.26	2.59	1.83	1.36	.97
Kjeldahl-N	.32	.78	1.19	.92	1.04	1.10
Dissolved solids	232.00	240.00	251.00	286.00	244.00	216.00
Total suspended solids	14.00	10.00	13.00	10.00	14.00	12.00
Volatile suspended solids	9.00	8.00	10.00	3.00	5.00	7.00

Parameter	7/29/85	8/12/85	8/26/85	9/09/85	9/20/85	10/07/85
Turbidity, NTU	13.00	11.00	16.00	18.00	16.00	17.00
pH (dimensionless)	9.00	8.40	8.20	8.10	8.20	8.20
Alkalinity	110.00	122.00	123.00	121.00	123.00	121.00
Conductivity, umho/cm	310.00	318.00	319.00	325.00	329.00	339.00
Total phosphate-P	.09	.08	.07	.07	.07	.07
Dissolved phosphate-P	.03	.03	.02	.02	.01	.01
Total ammonia-N	.01	.08	.26	.15	.17	.23
Nitrate-N	.34	.21	.09	.12	.15	.13
Kjeldahl-N	.72	.87	.71	.72	1.04	.60
Dissolved solids	226.00	216.00	220.00	228.00	216.00	246.00
Total suspended solids	14.00	17.00	16.00	18.00	13.00	19.00
Volatile suspended solids	6.00	8.00	5.00	6.00	10.00	4.00

Parameter	11/14/85	3/18/86	3/31/86	4/14/86	4/28/86	5/12/86
Turbidity, NTU	17.00	33.00	31.00	17.00	10.00	10.00
pH (dimensionless)	8.45	8.23	8.70	8.35	8.30	8.55
Alkalinity	136.00	142.00	143.00	154.00	157.00	156.00
Conductivity, umho/cm	380.00	394.00	406.00	418.00	416.00	415.00
Total phosphate-P	.10	.11	.09	.08	.07	.05
Dissolved phosphate-P	.02	.02	.02	.01	.03	.02
Total ammonia-N	.16	.08	.12	.09	.25	.06
Nitrate-N	1.57	3.75	6.54	3.50	3.45	2.93
Kjeldahl-N	1.65	1.29	1.53	1.23	.91	1.05
Dissolved solids	266.00	286.00	298.00	270.00	354.00	284.00
Total suspended solids	14.00	24.00	30.00	16.00	18.00	7.00
Volatile suspended solids	2.00	8.00	18.00	11.00	3.00	5.00

Note: Values in mg/L unless otherwise indicated

Appendix 5B. Physical and Chemical Quality Characteristics of Mid-Depth Waters in Dawson Lake, Deep Station, concluded

Parameter	5/27/86
Turbidity, NTU	8.00
pH (dimensionless)	8.35
Alkalinity	151.00
Conductivity, µmho/cm	410.00
Total phosphate-P	.04
Dissolved phosphate-P	0.00
Total ammonia-N	.29
Nitrate-N	2.48
Kjeldahl-N	.83
Dissolved solids	310.00
Total suspended solids	14.00
Volatile suspended solids	5.00

Note: Values in mg/L unless otherwise indicated

Appendix 5C. Physical and Chemical Quality Characteristics of Near-Bottom Waters in Dawson Lake, Deep Station

Parameter	5/06/85	5/20/85	6/03/85	6/17/85	7/01/85	7/15/85
Turbidity, NTU	19.00	23.00	25.00	25.00	35.00	23.00
pH (dimensionless)	8.60	7.90	7.80	7.80	7.70	7.60
Alkalinity	111.00	115.00	130.00	134.00	149.00	158.00
Conductivity, µmho/cm	272.00	284.00	285.00	291.00	295.00	373.00
Total phosphate-P	.09	.07	.08	.09	.15	.18
Dissolved phosphate-P	.02	.01	0.00	.02	0.00	.02
Total ammonia-N	.07	.22	.38	.70	1.22	1.36
Nitrate-N	3.90	3.09	1.98	1.40	.35	.19
Kjeldahl-N	.47	.99	1.37	1.46	1.95	2.35
Dissolved solids	233.00	248.00	229.00	274.00	233.00	242.00
Total suspended solids	18.00	19.00	29.00	28.00	40.00	28.00
Volatile suspended solids	8.00	8.00	13.00	2.00	8.00	9.00

Parameter	7/29/85	8/12/85	8/26/85	9/09/85	9/20/85	10/07/85
Turbidity, NTU	26.00	15.00	62.00	34.00	25.00	84.00
pH (dimensionless)	7.70	7.70	7.80	7.40	7.80	8.30
Alkalinity	130.00	123.00	158.00	158.00	125.00	123.00
Conductivity, umho/cm	348.00	330.00	356.00	377.00	333.00	335.00
Total phosphate-P	.05	.08	.15	.36	.08	.17
Dissolved phosphate-P	.02	.02	.02	.18	.01	.02
Total ammonia-N	.71	.45	1.90	2.16	.41	.21
Nitrate-N	.04	.20	.12	.07	.11	.93
Kjeldahl-N	1.08	1.11	2.91	3.04	1.23	1.15
Dissolved solids	224.00	220.00	250.00	246.00	204.00	274.00
Total suspended solids	27.00	18.00	69.00	35.00	20.00	106.00
Volatile suspended solids	4.00	7.00	8.00	11.00	17.00	15.00

Parameter	11/14/85	3/18/86	3/31/86	4/14/86	4/28/86	5/12/86
Turbidity, NTU	21.00	57.00	45.00	33.00	18.00	21.00
pH (dimensionless)	8.40	8.18	8.30	8.30	8.00	7.75
Alkalinity	149.00	142.00	146.00	154.00	162.00	171.00
Conductivity, umho/cm	385.00	395.00	408.00	418.00	427.00	438.00
Total phosphate-P	.11	.14	.14	.09	.09	.40
Dissolved phosphate-P	.02	.02	.05	.01	.02	.16
Total ammonia-N	.20	1.00	.23	.30	.36	.91
Nitrate-N	1.62	.12	4.22	3.58	3.30	2.38
Kjeldahl-N	1.59	3.17	1.60	1.32	1.33	1.56
Dissolved solids	266.00	300.00	316.00	262.00	346.00	287.00
Total suspended solids	13.00	55.00	46.00	32.00	26.00	19.00
Volatile suspended solids	3.00	11.00	22.00	11.00	6.00	7.00

Note: Values in mg/L unless otherwise indicated

Appendix 5C. Physical and Chemical Quality Characteristics of Near-Bottom Waters in Dawson Lake, Deep Station, concluded

Parameter	5/27/86
Turbidity, NTU	12.00
pH (dimensionless)	7.55
Alkalinity	17 9.00
Conductivity, umho/cm	441.00
Total phosphate-P	.04
Dissolved phosphate-P	.02
Total amnionia-N	.78
Nitrate-N	1.45
Kjeldahl-N	1.51
Dissolved solids	308.00
Total suspended solids	14.00
Volatile suspended solids	5.00

Note: Values in mg/L unless otherwise indicated

Appendix 6. Physical and Chemical Quality Characteristics of Surface Waters in Dawson Lake, Shallow Station

Parameter	5/08/85	5/20/85	8/03/85	8/17/85	7/01/85	7/15/85
Secchi, inches	8.00	25.00	17.00	25.00	22.00	11.00
Turbidity, NIU	28.00	20.00	21.00	16.00	13.00	27.00
pH (dimensionless)	9.10	8.40	8.70	8.50	8.60	8.90
Alkalinity	125.00	121.00	124.00	126.00	117.00	112.00
Conductivity, µmho/cm	305.00	281.00	279.00	27 9.00	263.00	312.00
Total phosphate-P	.13	.04	.09	.06	.06	.11
Dissolved phosphate-P	.02	0.00	.01	.01	.01	.02
Total ammonia-N	.06	.13	.10	.17	.01	.04
Nitrate-N	5.42	3.41	2.38	2.45	1.30	.88
Kjeldahl-N	.79	1.18	1.42	.70	1.19	1.41
Dissolved solids	251.00	256.00	236.00	284.00	218.00	204.00
Total suspended solids	40.00	21.00	24.00	15.00	17.00	28.00
Volatile suspended solids	16.00	18.00	11.00	4.00	6.00	10.00

Parameter	7/29/85	8/12/85	8/26/85	9/09/85	9/20/85	10/07/85
Secchi, inches	24.00	18.00	17.00	13.00	14.00	17.00
Turbidity, NIU	14.00	17.00	24.00	32.00	32.00	17.00
pH (dimensionless)	9.00	8.70	8.70	8.20	8.80	8.60
Alkalinity	114.00	114.00	121.00	114.00	127.00	130.00
Conductivity, umho/cm	315.00	322.00	316.00	327.00	331.00	335.00
Total phosphate-P	.08	.07	.10	.15	.11	.12
Dissolved phosphate-P	.03	.04	.03	.04	.01	.01
Total ammonia-N	.15	.08	.13	.08	.26	.10
Nitrate-N	.25	.21	.07	.06	.10	.08
Kjeldahl-N	1.15	1.08	1.23	1.41	1.29	1.01
Dissolved solids	218.00	210.00	228.00	242.00	208.00	23 8.00
Total suspended solids	13.00	23.00	27.00	33.00	27.00	23.00
Volatile suspended solids	5.00	9.00	8.00	9.00	10.00	8.00

Parameter	11/14/85	3/18/86	3/31/86	4/14/86	4/28/86	5/12/86
Secchi, inches	3.00	9.00	13.00	15.00	14.00	31.00
Turbidity, NIU	143.00	42.00	27.00	27.00	32.00	14.00
pH (dimensionless)	7.65	8.34	8.70	8.36	8.22	8.50
Alkalinity	157.00	151.00	156.00	153.00	161.00	165.00
Conductivity, umho/cm	430.00	426.00	430.00	418.00	431.00	432.00
Total phosphate-P	.24	.10	.07	.09	.10	.04
Dissolved phosphate-P	.04	.04	.02	.02	.02	.01
Total ammonia-N	.41	.47	.15	.23	.29	.18
Nitrate-N	5.34	5.18	4.68	3.60	3.23	3.26
Kjeldahl-N	1.84	1.20	1.38	1.34	1.31	1.28
Dissolved solids	288.00	302.00	300.00	272.00	338.00	285.00
Total suspended solids	124.00	32.00	30.00	22.00	41.00	12.00
Volatile suspended solids	8.00	7.00	19.00	10.00	6.00	9.00

Note: Values in mg/L unless otherwise indicated

Appendix 6. Physical and Chemical Quality Characteristics of Surface Waters in Dawson Lake, Shallow Station, concluded

Parameter	5/27/86
Secchi, inches	21.00
Turbidity, NTU	16.00
pH (dimensionless)	8.35
Alkalinity	158.00
Conductivity, umho/cm	424.00
Total phosphate-P	.05
Dissolved phosphate-P	.01
Total ammonia-N	.17
Nitrate-N	2.74
Kjeldahl-N	.80
Dissolved solids	284.00
Total suspended solids	21.00
Volatile suspended solids	5.00

Note: Values in mg/L unless otherwise indicated

Appendix 7. North Fork Salt Creek Water Quality Characteristics Upstream of the Lake

Parameter	5/06/85	5/20/85	6/03/85	6/17/85	7/01/85	7/15/85
Turbidity, NTU	6.00	7.00	7.00	5.00	5.00	58.00
pH (dimensionless)	8.05	8.10	8.30	7.80	7.80	7.10
Alkalinity	187.00	194.00	199.00	211.00	216.00	153.00
Conductivity, μmho/cm	549.00	512.00	500.00	524.00	535.00	446.00
Total phosphate-P	.04	.04	.02	.02	.02	.20
Dissolved phosphate-P	.02	.01	.01	.02	.02	.11
Total ammonia-N	.01	.10	.03	.06	.05	.11
Nitrate-N	15.92	16.08	15.20	17.44	16.10	9.07
Kjeldahl-N	.19	.14	.50	.22	.13	1.08
Dissolved solids	367.00	406.00	398.00	428.00	-----	-----
Total suspended solids	3.00	20.00	5.00	4.00	5.00	43.00
Volatile suspended solids	3.00	9.00	4.00	1.00	2.00	5.00

Parameter	7/29/85	8/12/85	8/26/85	9/09/85	9/20/85	10/07/85
Turbidity, NTU	21.00	-----	17.00	44.00	-----	-----
pH (dimensionless)	8.10	-----	8.20	8.00	-----	-----
Alkalinity	259.00	-----	261.00	274.00	-----	-----
Conductivity, μmho/cm	686.00	-----	658.00	678.00	-----	-----
Total phosphate-P	.07	-----	.04	.12	-----	-----
Dissolved phosphate-P	.01	-----	.03	.04	-----	-----
Total ammonia-N	.16	-----	.05	.56	-----	-----
Nitrate-N	11.20	-----	7.24	7.85	-----	-----
Kjeldahl-N	.19	-----	.58	.59	-----	-----
Total suspended solids	16.00	-----	17.00	40.00	-----	-----
Volatile suspended solids	2.00	-----	5.00	10.00	-----	-----

Parameter	11/14/85	3/18/86	3/31/86	4/14/86	4/28/86	5/12/86
Turbidity, NTU	514.00	7.00	13.00	13.00	10.00	4.00
pH (dimensionless)	7.20	7.75	7.85	8.02	8.06	8.10
Alkalinity	82.00	214.00	224.00	222.00	218.00	225.00
Conductivity, μmho/cm	263.00	618.00	634.00	621.00	615.00	647.00
Total phosphate-P	.97	.03	.03	.02	.02	.01
Dissolved phosphate-P	.38	.02	.02	.01	.02	.01
Total ammonia-N	.28	.24	.07	.03	.08	.16
Nitrate-N	3.86	12.00	12.20	11.60	11.10	1.26
Kjeldahl-N	3.38	.26	.35	.08	.18	1.26
Total suspended solids	280.00	6.00	14.00	8.00	17.00	8.00
Volatile suspended solids	28.00	1.00	9.00	5.00	2.00	6.00

Note: Values in mg/L unless otherwise indicated

Appendix 7. North Fork Salt Creek Water Quality Characteristics Upstream of the Lake, concluded

Parameter	5/27/86
Turbidity, NTU	7.00
pH (dimensionless)	7.60
Alkalinity	227.00
Conductivity, µmho/cm	661.00
Total phosphate-P	.04
Dissolved phosphate-P	0.00
Total ammonia-N	.09
Nitrate-N	14.90
Kjeldahl-N	.16
Total suspended solids	28.00
Volatile suspended solids	5.00

Note: Values in mg/L unless otherwise indicated

Appendix 8. North Fork Salt Creek Water Quality Characteristics Downstream of the Lake

Parameter	5/06/85	5/20/85	6/03/85	6/17/85	7/01/85	7/15/85
Turbidity, NTU	13.00	6.00	10.00	15.00	9.00	9.00
pH (dimensionless)	8.50	8.00	8.80	8.60	8.70	8.90
Alkalinity	108.00	121.00	121.00	123.00	112.00	114.00
Conductivity, µmho/cm	271.00	289.00	272.00	273.00	256.00	321.00
Total phosphate-P	.07	.01	.05	.12	.05	.06
Dissolved phosphate-P	.02	.01	.01	.01	.01	.01
Total ammonia-N	.03	.17	.11	.14	.06	.05
Nitrate-N	3.77	3.19	2.61	1.88	1.34	.98
Kjeldahl-N	.80	.86	1.14	1.53	1.55	1.47
Dissolved solids	211.00	252.00	230.00	274.00	-----	-----
Total suspended solids	10.00	3.00	9.00	25.00	12.00	10.00
Volatile suspended solids	5.00	2.00	8.00	5.00	5.00	6.00

Parameter	7/29/85*	8/12/85*	8/26/85*	9/09/85*	9/20/85*	10/07/85
Turbidity, NTU						20.00
pH (dimensionless)						8.30
Alkalinity						127.00
Conductivity, µmho/cm						335.00
Total phosphate-P						.07
Dissolved phosphate-P						.01
Total ammonia-N						.23
Nitrate-N						.12
Kjeldahl-N						.83
Total suspended solids						22.00
Volatile suspended solids						5.00

Parameter	11/14/85	3/18/86	3/31/86	4/14/86	4/28/86	5/12/86
Turbidity, NTU	16.00	30.00	27.00	14.00	10.00	8.00
pH (dimensionless)	8.50	8.21	8.80	8.32	8.43	8.50
Alkalinity	145.00	140.00	146.00	153.00	160.00	154.00
Conductivity, µmho/cm	381.00	395.00	405.00	419.00	422.00	411.00
Total phosphate-P	.11	.10	.09	.06	.04	.03
Dissolved phosphate-P	.02	.02	.01	.01	.01	.02
Total ammonia-N	.06	.37	.18	.43	.19	.70
Nitrate-N	1.73	3.92	4.32	3.51	3.45	3.00
Kjeldahl-N	1.71	1.18	1.42	.88	1.07	.90
Total suspended solids	19.00	22.00	28.00	10.00	15.00	9.00
Volatile suspended solids	3.00	6.00	17.00	9.00	3.00	7.00

*On these dates there was no flow in the creek downstream of the lake

Note: Values in mg/L unless otherwise indicated

Appendix 8. North Fork Salt Creek Water Quality Characteristics Downstream of the Lake, concluded

Parameter	5/27/86
Turbidity, NIU	6.00
pH (dimensionless)	8.40
Alkalinity	145.00
Conductivity, umho/ctn	400.00
Total phosphate-P	.03
Dissolved phosphate-P	0.00
Total ammonia-N	.09
Nitrate-N	2.48
Kjeldahl-N	.98
Total suspended solids	12.00
Volatile suspended solids	3.00

Note: Values in mg/L unless otherwise indicated

Appendix 9. Rainwater Characteristics

Parameter	5/15/85	6/03/85	7/03/85	7/17/85	7/26/85	8/02/85
Turbidity, NTU	-----	-----	9.00	10.00	14.00	-----
Total phosphate-P	1.60	.28	.16	.14	.16	.20
Dissolved phosphate-P	.25	.19	.09	.11	.12	.10
Total ammonia-N	5.69	1.81	1.05	.37	.62	.84
Nitrate-N	2.23	1.64	.96	.61	.83	.94
Total suspended solids	-----	13.00	5.00	8.00	7.00	27.00
Volatile suspended solids	-----	12.00	3.00	6.00	2.00	13.00

Parameter	8/06/85	8/10/85	8/15/85	9/09/85	10/19/85	11/19/85
Turbidity, NTU	-----	-----	-----	-----	8.00	-----
Total phosphate-P	.09	.10	.05	.04	.04	.08
Dissolved phosphate-P	.07	-----	.04	.02	.01	.03
Total ammonia-N	.53	.73	.21	.12	.45	.05
Nitrate-N	.78	1.22	.36	.68	.52	.17
Total suspended solids	6.00	16.00	8.00	9.00	8.00	18.00
Volatile suspended solids	6.00	14.00	6.00	7.00	2.00	12.00

Parameter	12/11/85
Total phosphate-P	.23
Dissolved phosphate-P	.02
Total ammonia-N	.26
Nitrate-N	.63
Total suspended solids	53.00

Note: Values in mg/L unless otherwise indicated

Appendix 10. Backwash Water Characteristics after Its Treatment through the Sand Bed

Parameter	5/02/85	5/09/85	5/17/85	5/30/85	6/07/85	7/01/85
Turbidity, NTU	-----	-----	-----	-----	68.00	62.00
Total phosphate-P	.16	.07	.09	.24	.25	.33
Dissolved phosphate-P	.10	.06	.04	.06	.04	.06
Total ammonia-N	.72	1.17	.24	1.52	.10	.33
Nitrate-N	9.84	3.08	7.91	6.08	11.88	10.40
Total suspended solids	-----	-----	-----	21.00	67.00	51.00
Volatile suspended solids	-----	-----	-----	8.00	4.00	5.00

Parameter	7/11/85	7/18/85	7/25/85	8/01/85	8/08/85	8/15/85
Turbidity, NTU	64.00	36.00	21.00	-----	-----	-----
Total phosphate-P	.25	.17	.14	.13	.13	.13
Dissolved phosphate-P	.06	.06	.07	.05	.05	.04
Total ammonia-N	.48	.59	1.07	.80	.81	.03
Nitrate-N	8.91	10.90	8.97	10.60	11.50	14.40
Total suspended solids	50.00	31.00	15.00	20.00	16.00	49.00
Volatile suspended solids	2.00	2.00	1.00	2.00	5.00	7.00

Parameter	8/22/85	8/30/85	9/05/85	9/12/85	9/17/85	9/26/85
Turbidity, NTU	-----	15.00	20.00	8.00	13.00	33.00
Total phosphate-P	.13	.11	.12	.10	.10	.16
Dissolved phosphate-P	.06	.06	.07	.07	.07	.07
Total ammonia-N	.25	.97	1.51	1.36	1.22	1.13
Nitrate-N	10.80	8.88	7.51	7.50	7.57	10.27
Total suspended solids	36.00	15.00	19.00	9.00	11.00	23.00
Volatile suspended solids	6.00	4.00	4.00	2.00	2.00	2.00

Parameter	10/03/85	10/17/85	10/24/85	10/31/85	11/10/85	11/18/85
Turbidity, NTU	27.00	24.00	33.00	22.00	23.00	-----
Total phosphate-P	.14	.12	.12	.11	.13	.09
Dissolved phosphate-P	.06	.07	.07	.07	.07	.05
Total ammonia-N	1.26	1.17	1.02	1.63	1.36	.80
Nitrate-N	7.50	8.60	9.55	6.85	7.43	5.89
Total suspended solids	19.00	17.00	27.00	13.00	16.00	7.00
Volatile suspended solids	2.00	0.00	0.00	0.00	3.00	4.00

Parameter	11/25/85	12/02/85	12/09/85	1/09/86	1/16/86	1/23/86
Turbidity, NTU	-----	-----	-----	-----	9.00	12.00
Total phosphate-P	.10	.07	.09	.08	.09	.10
Dissolved phosphate-P	.06	.05	.06	.05	.06	.05
Total ammonia-N	1.32	1.08	1.31	1.50	1.30	1.11
Nitrate-N	5.13	5.92	4.08	6.07	7.91	7.71
Total suspended solids	9.00	7.00	8.00	10.00	7.00	12.00
Volatile suspended solids	7.00	3.00	-----	-----	-----	-----

Note: Values in mg/L unless otherwise indicated

Appendix 10. Backwash Water Characteristics after Its Treatment through the Sand Bed, concluded

Parameter	1/30/86	2/06/86	2/12/86	2/20/86	2/27/86	3/06/86
Turbidity, NTU	12.00	14.00	-----	-----	-----	-----
Total phosphate-P	.06	.10	.09	.10	.10	.10
Dissolved phosphate-P	.09	.05	.05	.05	.05	.05
Total ammonia-N	1.48	.90	1.28	1.27	.81	1.31
Nitrate-N	8.42	10.40	6.49	9.35	8.81	9.13
Total suspended solids	7.00	8.00	10.00	13.00	12.00	15.00
Volatile suspended solids	-----	-----	2.00	3.00	2.00	1.00

Parameter	3/13/86	3/20/86	4/03/86
Turbidity, NTU	-----	13.00	-----
Total phosphate-P	.08	.09	.13
Dissolved phosphate-P	.06	.05	.06
Total ammonia-N	1.23	1.22	1.16
Nitrate-N	4.72	10.75	8.72
Volatile suspended solids	2.00	6.00	3.00

Note: Values in mg/L unless otherwise indicated